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(54) **VESSEL SEALER AND DIVIDER**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

371,664 A 10/1887 Brannan et al.
702,472 A 6/1902 Pignolet
(Continued)

FOREIGN PATENT DOCUMENTS

CA 2104423 A1 2/1994
CA 2520413 A1 3/2007
(Continued)

OTHER PUBLICATIONS

LigaSure Vessel Sealing System, the Seal of Confidence in General, Gynecologic, Urologic, and Laparaoscopic Surgery Sales/Product Literature; Jan. 2004.

(Continued)

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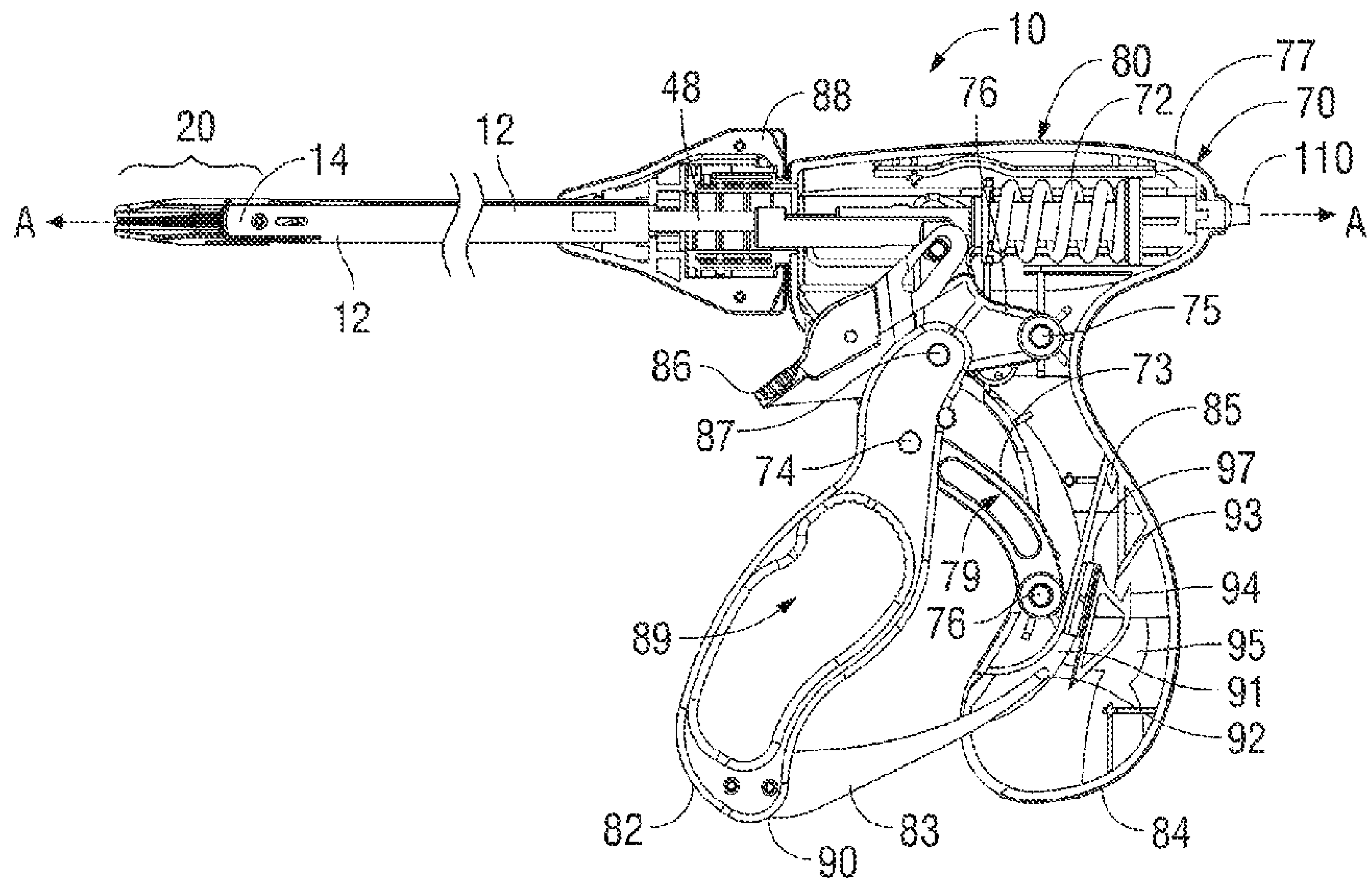
(57) **ABSTRACT**

A bipolar forceps includes an elongated shaft having opposing jaw members at a distal end thereof. The jaw members are movable relative to one another from a first position wherein the jaw members are disposed in spaced relation relative to one another to a second position wherein the jaw members cooperate to grasp tissue therebetween. The jaws members are connected to a source of electrical energy such that the jaw members are capable of conducting energy through tissue held therebetween to effect a tissue seal. At least one non-conductive and spaced-apart stop member is disposed on an inner-facing surface of the jaw members to regulate the gap distance between the jaw members when tissue is held therebetween. The forceps also includes a longitudinally reciprocating knife which severs the tissue after sealing at a location which is proximate the sealing site.

13 Claims, 6 Drawing Sheets



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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

728,883 A 5/1903 Downes
1,586,645 A 6/1926 Bierman
1,813,902 A 7/1931 Bovie
1,822,330 A 9/1931 Ainslie
1,852,542 A 4/1932 Sovatkin
1,908,201 A 5/1933 Welch et al.
1,918,889 A 7/1933 Bacon
2,002,594 A 5/1935 Wappler et al.
2,011,169 A 8/1935 Wappler et al.
2,031,682 A 2/1936 Wappler et al.
2,054,149 A 9/1936 Wappler
2,113,246 A 4/1938 Wappler
2,141,936 A 12/1938 Schmitt
2,176,479 A 10/1939 Willis
2,245,030 A 6/1941 Gottesfeld et al.
2,279,753 A 4/1942 Knopp
2,305,156 A 12/1942 Grubel
2,327,353 A 8/1943 Karle
2,632,661 A 3/1953 Cristofv
2,668,538 A 2/1954 Baker
2,796,065 A 6/1957 Kapp
2,824,915 A 2/1958 Buturuga
3,073,311 A 1/1963 Tibbs et al.
3,100,489 A 8/1963 Bagley
3,204,807 A 9/1965 Ramsing
3,372,288 A 3/1968 Wigington
3,459,187 A 8/1969 Pallotta
3,561,448 A 2/1971 Peternel
3,643,663 A 2/1972 Sutter
3,648,001 A 3/1972 Anderson et al.
3,651,811 A 3/1972 Hildebrandt et al.
3,678,229 A 7/1972 Osika
3,720,896 A 3/1973 Beierlein
3,763,726 A 10/1973 Hildebrand
3,779,918 A 12/1973 Ikeda et al.
3,798,688 A 3/1974 Wasson
3,801,766 A 4/1974 Morrison, Jr.
3,839,614 A 10/1974 Saganowski et al.
3,862,630 A 1/1975 Balamuth
3,863,339 A 2/1975 Reaney et al.
3,866,610 A 2/1975 Kletschka
3,875,945 A 4/1975 Friedman
3,897,786 A 8/1975 Garnett et al.
3,911,766 A 10/1975 Fridolph et al.
3,920,021 A 11/1975 Hiltebrandt
3,921,641 A 11/1975 Hulka
3,938,527 A 2/1976 Rioux et al.
3,952,749 A 4/1976 Fridolph et al.
3,970,088 A 7/1976 Morrison
3,987,795 A 10/1976 Morrison
4,005,714 A 2/1977 Hiltebrandt
4,016,881 A 4/1977 Rioux et al.
4,031,898 A 6/1977 Hiltebrandt et al.
4,041,952 A 8/1977 Morrison, Jr. et al.
4,043,342 A 8/1977 Morrison, Jr.
4,074,718 A 2/1978 Morrison, Jr.
4,076,028 A 2/1978 Simmons
4,080,820 A 3/1978 Allen
4,088,134 A 5/1978 Mazzariello
4,102,471 A 7/1978 Lore et al.
D249,549 S 9/1978 Pike
4,112,950 A 9/1978 Pike
4,127,222 A 11/1978 Adams
4,128,099 A 12/1978 Bauer
4,165,746 A 8/1979 Burgin
4,187,420 A 2/1980 Piber
4,200,104 A 4/1980 Harris
4,200,105 A 4/1980 Gonser
4,233,734 A 11/1980 Bies
4,236,470 A 12/1980 Stenson
4,274,413 A 6/1981 Hahn et al.
4,300,564 A 11/1981 Furihata
4,306,561 A 12/1981 de Medinaceli
4,311,145 A 1/1982 Esty et al.
D263,020 S 2/1982 Rau, III
4,315,510 A 2/1982 Kihn
4,363,944 A 12/1982 Poirier
4,370,980 A 2/1983 Lottick
4,375,218 A 3/1983 DiGeronimo
4,394,552 A 7/1983 Schlosser
4,416,276 A 11/1983 Newton et al.
4,418,692 A 12/1983 Guay
4,443,935 A 4/1984 Zamba et al.
4,452,246 A 6/1984 Bader et al.
4,470,786 A 9/1984 Sano et al.
4,492,231 A 1/1985 Auth
4,493,320 A 1/1985 Treat
4,503,855 A 3/1985 Maslanka
4,506,669 A 3/1985 Blake, III
4,509,518 A 4/1985 McGarry et al.
4,513,271 A 4/1985 Reisem
4,535,773 A 8/1985 Yoon
4,552,143 A 11/1985 Lottick
4,574,804 A 3/1986 Kurwa
4,597,379 A 7/1986 Kihn et al.
4,600,007 A 7/1986 Lahodny et al.
4,619,258 A 10/1986 Pool
4,624,254 A 11/1986 McGarry et al.
4,625,723 A 12/1986 Altnether et al.
4,644,950 A 2/1987 Valli
4,655,215 A 4/1987 Pike
4,655,216 A 4/1987 Tischer
4,657,016 A 4/1987 Garito et al.
4,662,372 A 5/1987 Sharkany et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,671,274 A		6/1987	Sorochenko
4,674,499 A		6/1987	Pao
4,685,459 A		8/1987	Koch et al.
4,733,662 A		3/1988	DeSatnick et al.
D295,893 S		5/1988	Sharkany et al.
D295,894 S		5/1988	Sharkany et al.
4,753,235 A		6/1988	Hasson
4,754,892 A		7/1988	Retief
4,761,175 A		8/1988	Schirmer et al.
4,763,669 A		8/1988	Jaeger
D298,353 S		11/1988	Manno
4,781,175 A		11/1988	McGreevy et al.
D299,413 S		1/1989	DeCarolis
4,805,616 A		2/1989	Pao
4,827,927 A		5/1989	Newton
4,827,929 A		5/1989	Hodge
4,829,313 A		5/1989	Taggart
4,846,171 A		7/1989	Kauphusman et al.
4,887,612 A		12/1989	Esser et al.
4,890,610 A		1/1990	Kirwan, Sr. et al.
4,938,761 A		7/1990	Ensslin
4,947,009 A		8/1990	Osika et al.
4,973,801 A		11/1990	Frick et al.
4,985,030 A		1/1991	Melzer et al.
5,007,908 A		4/1991	Rydell
5,019,678 A		5/1991	Templeton et al.
5,026,370 A		6/1991	Lottick
5,026,371 A		6/1991	Rydell et al.
5,035,695 A		7/1991	Weber, Jr. et al.
5,037,433 A		8/1991	Wilk et al.
5,042,707 A		8/1991	Taheri
5,047,046 A		9/1991	Bodoia
5,052,402 A		10/1991	Bencini et al.
5,078,716 A		1/1992	Doll
5,084,057 A		1/1992	Green et al.
5,085,659 A		2/1992	Rydell
5,099,840 A		3/1992	Goble et al.
5,100,430 A		3/1992	Avellanet et al.
5,108,392 A		4/1992	Spingler
5,112,343 A		5/1992	Thornton
5,116,332 A		5/1992	Lottick
5,122,139 A		6/1992	Sutter
5,144,323 A		9/1992	Yonkers
5,147,357 A		9/1992	Rose et al.
5,151,102 A		9/1992	Kamiyama et al.
5,151,978 A		9/1992	Bronikowski et al.
5,158,561 A		10/1992	Rydell et al.
5,169,396 A		12/1992	Dowlatshahi et al.
5,176,695 A		1/1993	Dulebohn
5,176,702 A	*	1/1993	Bales A61B 17/2909 606/208
5,190,541 A		3/1993	Abele et al.
5,196,009 A		3/1993	Kirwan, Jr.
5,197,964 A		3/1993	Parins
5,209,747 A		5/1993	Knoepfler
5,211,655 A		5/1993	Hasson
5,215,101 A		6/1993	Jacobs et al.
5,217,457 A		6/1993	Delahuerga et al.
5,217,458 A		6/1993	Parins
5,217,460 A		6/1993	Knoepfler
5,219,354 A		6/1993	Choudhury et al.
5,231,997 A		8/1993	Kikuchi et al.
5,244,462 A		9/1993	Delahuerga et al.
5,250,047 A		10/1993	Rydell
5,250,056 A		10/1993	Hasson
5,250,063 A		10/1993	Abidin et al.
5,254,129 A		10/1993	Alexander
5,258,001 A		11/1993	Corman
5,258,006 A		11/1993	Rydell et al.
5,261,918 A		11/1993	Phillips et al.
5,267,998 A		12/1993	Hagen
5,269,780 A		12/1993	Roos
5,269,804 A		12/1993	Bales et al.
D343,453 S		1/1994	Noda
5,275,615 A		1/1994	Rose
5,277,201 A		1/1994	Stern
5,281,220 A		1/1994	Blake, III
5,282,799 A		2/1994	Rydell
5,282,800 A		2/1994	Foshee et al.
5,282,826 A		2/1994	Quadri
5,290,286 A		3/1994	Parins
5,290,287 A		3/1994	Boebel et al.
5,300,082 A		4/1994	Shame et al.
5,304,203 A		4/1994	El-Mallawany et al.
5,308,353 A		5/1994	Beurrier
5,308,357 A		5/1994	Lichtman
5,312,433 A		5/1994	Boebel et al.
5,313,027 A		5/1994	Inoue et al.
5,314,445 A		5/1994	Heidmueller et al.
5,314,463 A		5/1994	Camps et al.
5,318,589 A		6/1994	Lichtman
5,324,289 A		6/1994	Eggers
D348,930 S		7/1994	Olson
5,326,806 A		7/1994	Yokoshima et al.
5,330,471 A		7/1994	Eggers
5,330,502 A		7/1994	Hassler et al.
D349,341 S		8/1994	Lichtman et al.
5,334,166 A		8/1994	Palestrant
5,334,183 A		8/1994	Wuchinich
5,334,215 A		8/1994	Chen
5,336,220 A		8/1994	Ryan et al.
5,336,221 A		8/1994	Anderson
5,342,359 A		8/1994	Rydell
5,342,381 A		8/1994	Tidemand
5,342,393 A		8/1994	Stack
5,344,424 A		9/1994	Roberts et al.
5,350,391 A		9/1994	Iacovelli
5,352,222 A		10/1994	Rydell
5,354,271 A		10/1994	Voda
5,356,408 A		10/1994	Rydell
5,359,993 A		11/1994	Slater et al.
5,366,477 A		11/1994	LeMarie, III et al.
5,367,250 A		11/1994	Whisenand
5,368,600 A		11/1994	Failla et al.
5,374,277 A		12/1994	Hassler
5,376,089 A		12/1994	Smith
5,376,094 A		12/1994	Kline
D354,564 S		1/1995	Medema
5,383,875 A		1/1995	Bays et al.
5,383,880 A		1/1995	Hooven
5,383,897 A		1/1995	Wholey
5,389,098 A		2/1995	Tsuruta et al.
5,389,103 A		2/1995	Melzer et al.
5,389,104 A		2/1995	Hahnen et al.
5,391,166 A		2/1995	Eggers
5,391,183 A		2/1995	Janzen et al.
5,395,360 A		3/1995	Manoukian
5,396,194 A		3/1995	Williamson et al.
5,396,900 A		3/1995	Slater et al.
5,397,325 A		3/1995	Della Badia et al.
5,403,312 A		4/1995	Yates et al.
5,403,342 A		4/1995	Tovey et al.
5,405,344 A		4/1995	Williamson et al.
5,409,763 A		4/1995	Serizawa et al.
D358,887 S		5/1995	Feinberg
5,411,519 A		5/1995	Tovey et al.
5,411,520 A		5/1995	Nash et al.
5,413,571 A		5/1995	Katsaros et al.
5,415,656 A		5/1995	Tihon et al.
5,415,657 A		5/1995	Taymor-Luria
5,417,709 A		5/1995	Slater
5,422,567 A		6/1995	Matsunaga
5,423,810 A		6/1995	Goble et al.
5,425,690 A		6/1995	Chang
5,425,739 A		6/1995	Jessen
5,429,616 A		7/1995	Schaffer
5,431,672 A		7/1995	Cote et al.
5,431,674 A		7/1995	Basile et al.
5,437,277 A		8/1995	Dumoulin et al.
5,437,292 A		8/1995	Kipshidze et al.
5,438,302 A		8/1995	Goble
5,439,478 A		8/1995	Palmer
5,441,517 A		8/1995	Kensey et al.
5,443,463 A		8/1995	Stern et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,443,464 A 8/1995 Russell et al.
5,443,479 A 8/1995 Bressi, Jr.
5,443,480 A 8/1995 Jacobs et al.
5,445,622 A 8/1995 Brown
5,445,638 A 8/1995 Rydell et al.
5,445,658 A 8/1995 Durrfeld et al.
5,449,480 A 9/1995 Kuriya
5,451,224 A 9/1995 Goble et al.
5,454,739 A 10/1995 Strand
5,454,809 A 10/1995 Janssen
5,454,823 A 10/1995 Richardson et al.
5,454,827 A 10/1995 Aust et al.
5,456,684 A 10/1995 Schmidt et al.
5,458,598 A 10/1995 Feinberg et al.
5,460,629 A 10/1995 Shlain et al.
5,461,765 A 10/1995 Linden et al.
5,462,546 A 10/1995 Rydell
5,466,243 A * 11/1995 Schmieding A61F 2/0805 606/232
5,472,442 A 12/1995 Klicek
5,472,443 A 12/1995 Cordis et al.
5,476,479 A 12/1995 Green et al.
5,478,351 A 12/1995 Meade et al.
5,480,406 A 1/1996 Nolan et al.
5,480,409 A 1/1996 Riza
5,482,054 A 1/1996 Slater et al.
5,484,436 A 1/1996 Eggers et al.
5,493,899 A 2/1996 Beck et al.
5,496,312 A 3/1996 Klicek
5,496,317 A 3/1996 Goble et al.
5,496,347 A 3/1996 Hashiguchi et al.
5,499,997 A 3/1996 Sharpe et al.
5,501,654 A 3/1996 Failla et al.
5,509,922 A 4/1996 Aranyi et al.
5,512,721 A 4/1996 Young et al.
5,514,134 A 5/1996 Rydell et al.
5,520,702 A 5/1996 Sauer et al.
5,527,313 A 6/1996 Scott et al.
5,528,833 A 6/1996 Sakuma
5,529,067 A 6/1996 Larsen et al.
5,531,744 A 7/1996 Nardella et al.
5,536,251 A 7/1996 Evard et al.
5,540,684 A 7/1996 Hassler, Jr.
5,540,685 A 7/1996 Parins et al.
5,540,706 A 7/1996 Aust et al.
5,540,715 A 7/1996 Katsaros et al.
5,542,945 A 8/1996 Fritzsch
5,549,604 A 8/1996 Sutcu et al.
5,554,172 A 9/1996 Horner et al.
5,558,671 A 9/1996 Yates
5,558,672 A 9/1996 Edwards et al.
5,562,619 A 10/1996 Mirarchi et al.
5,562,699 A 10/1996 Heimberger et al.
5,562,720 A 10/1996 Stern et al.
5,564,615 A 10/1996 Bishop et al.
5,568,859 A 10/1996 Levy et al.
5,569,241 A 10/1996 Edwards
5,569,243 A 10/1996 Kortenbach et al.
5,571,100 A 11/1996 Goble et al.
5,573,424 A 11/1996 Poppe
5,573,534 A 11/1996 Stone
5,573,535 A 11/1996 Viklund
5,575,799 A 11/1996 Bolanos et al.
5,575,805 A 11/1996 Li
5,578,052 A 11/1996 Koros et al.
5,579,781 A 12/1996 Cooke
5,582,611 A 12/1996 Tsuruta et al.
5,582,617 A 12/1996 Klieman et al.
5,585,896 A 12/1996 Yamazaki et al.
5,590,570 A 1/1997 LeMaire, III et al.
5,591,181 A 1/1997 Stone et al.
5,597,107 A 1/1997 Knodel et al.
5,599,350 A 2/1997 Schulze et al.
5,601,224 A 2/1997 Bishop et al.
5,601,601 A 2/1997 Tal et al.
5,601,641 A 2/1997 Stephens
5,603,711 A 2/1997 Parins et al.
5,603,723 A 2/1997 Aranyi et al.
5,607,436 A 3/1997 Pratt et al.
5,611,798 A 3/1997 Eggers
5,611,808 A 3/1997 Hossain et al.
5,611,813 A 3/1997 Lichtman
5,618,294 A 4/1997 Aust et al.
5,618,307 A 4/1997 Donlon et al.
5,620,415 A 4/1997 Lucey et al.
5,620,453 A 4/1997 Nallakrishnan
5,620,459 A 4/1997 Lichtman
5,624,281 A 4/1997 Christensson
5,624,452 A 4/1997 Yates
5,626,578 A 5/1997 Tihon
5,626,607 A 5/1997 Malecki et al.
5,626,609 A 5/1997 Zvenyatsky et al.
5,630,833 A 5/1997 Katsaros et al.
5,637,110 A 6/1997 Pennybacker et al.
5,637,111 A 6/1997 Sutcu et al.
5,638,003 A 6/1997 Hall
5,638,827 A 6/1997 Palmer et al.
5,639,403 A 6/1997 Ida et al.
5,643,294 A 7/1997 Tovey et al.
5,647,869 A 7/1997 Goble et al.
5,647,871 A 7/1997 Levine et al.
5,649,959 A 7/1997 Hannam et al.
5,655,650 A 8/1997 Naitou
5,658,281 A 8/1997 Heard
D384,413 S 9/1997 Zlock et al.
5,662,667 A 9/1997 Knodel
5,665,100 A 9/1997 Yoon
5,667,526 A 9/1997 Levin
5,673,841 A 10/1997 Schulze et al.
5,674,220 A 10/1997 Fox et al.
5,674,229 A 10/1997 Tovey et al.
5,681,282 A 10/1997 Eggers et al.
5,688,270 A 11/1997 Yates et al.
5,690,652 A 11/1997 Wurster et al.
5,690,653 A 11/1997 Richardson et al.
5,693,051 A * 12/1997 Schulze A61B 17/07207 606/51
5,693,920 A 12/1997 Maeda
5,695,522 A 12/1997 LeMaire, III et al.
5,700,261 A 12/1997 Brinkerhoff
5,700,270 A 12/1997 Peyser et al.
5,702,390 A 12/1997 Austin et al.
5,707,369 A 1/1998 Vaitekunas et al.
5,709,680 A 1/1998 Yates et al.
5,713,895 A 2/1998 Lontine et al.
5,716,366 A 2/1998 Yates
5,720,742 A 2/1998 Zacharias
5,720,744 A 2/1998 Eggleston et al.
5,722,421 A 3/1998 Francese et al.
5,725,536 A 3/1998 Oberlin et al.
5,727,428 A 3/1998 LeMaire, III et al.
5,735,848 A 4/1998 Yates et al.
5,735,849 A 4/1998 Baden et al.
5,743,906 A 4/1998 Parins et al.
5,752,973 A 5/1998 Kieturakis
5,755,717 A 5/1998 Yates et al.
5,759,188 A 6/1998 Yoon
5,762,255 A 6/1998 Chrisman et al.
5,762,609 A 6/1998 Benaron et al.
5,766,130 A 6/1998 Selmonosky
5,766,166 A 6/1998 Hooven
5,766,170 A 6/1998 Eggers
5,766,196 A 6/1998 Griffiths
5,769,849 A 6/1998 Eggers
5,772,655 A 6/1998 Bauer et al.
5,772,670 A 6/1998 Brosa
5,776,128 A 7/1998 Eggers
5,776,130 A 7/1998 Buysse et al.
5,776,156 A 7/1998 Shikhman
5,777,519 A 7/1998 Simopoulos
5,779,646 A 7/1998 Koblish et al.
5,779,701 A 7/1998 McBrayer et al.
5,779,727 A 7/1998 Orejola
5,781,048 A 7/1998 Nakao et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

H1745 H 8/1998 Paraschac
5,791,231 A 8/1998 Cohn et al.
5,792,137 A 8/1998 Carr et al.
5,792,165 A 8/1998 Klieman et al.
5,792,177 A 8/1998 Kaseda
5,797,537 A 8/1998 Oberlin et al.
5,797,927 A 8/1998 Yoon
5,797,938 A 8/1998 Paraschac et al.
5,797,941 A 8/1998 Schulze et al.
5,797,958 A 8/1998 Yoon
5,797,959 A 8/1998 Castro et al.
5,800,448 A 9/1998 Banko
5,800,449 A 9/1998 Wales
5,807,393 A 9/1998 Williamson, IV et al.
5,810,764 A 9/1998 Eggers et al.
5,810,805 A 9/1998 Sutcu et al.
5,810,808 A 9/1998 Eggers
5,810,811 A 9/1998 Yates et al.
5,810,877 A 9/1998 Roth et al.
5,814,043 A 9/1998 Shapeton
5,814,054 A 9/1998 Kortenbach et al.
5,817,083 A 10/1998 Shemesh et al.
5,817,119 A 10/1998 Klieman et al.
5,820,630 A 10/1998 Lind
5,824,978 A 10/1998 Karasik et al.
5,827,271 A 10/1998 Buysse et al.
5,827,274 A 10/1998 Bonnet et al.
5,827,279 A 10/1998 Hughett et al.
5,827,281 A 10/1998 Levin
5,827,323 A 10/1998 Klieman et al.
5,827,548 A 10/1998 Lavallee et al.
5,830,212 A 11/1998 Cartmell et al.
5,833,690 A 11/1998 Yates et al.
5,833,695 A 11/1998 Yoon
5,836,072 A 11/1998 Sullivan et al.
D402,028 S 12/1998 Grimm et al.
5,843,080 A 12/1998 Fleenor et al.
5,849,020 A 12/1998 Long et al.
5,849,022 A 12/1998 Sakashita et al.
5,851,214 A 12/1998 Larsen et al.
5,853,412 A 12/1998 Mayenberger
5,859,527 A 1/1999 Cook
5,860,976 A 1/1999 Billings et al.
5,865,361 A 2/1999 Milliman et al.
5,876,401 A 3/1999 Schulze et al.
5,876,410 A 3/1999 Petillo
5,876,412 A 3/1999 Piraka
5,882,567 A 3/1999 Cavallaro et al.
D408,018 S 4/1999 McNaughton
5,891,141 A 4/1999 Rydell
5,891,142 A * 4/1999 Eggers A61B 18/1442
606/51
5,893,848 A 4/1999 Negus et al.
5,893,863 A 4/1999 Yoon
5,893,875 A 4/1999 O'Connor et al.
5,893,877 A 4/1999 Gampp, Jr. et al.
5,897,563 A 4/1999 Yoon et al.
5,902,301 A 5/1999 Olig
5,906,630 A 5/1999 Anderhub et al.
5,907,140 A 5/1999 Smith
5,908,420 A 6/1999 Parins et al.
5,908,432 A 6/1999 Pan
5,911,719 A 6/1999 Eggers
5,913,874 A 6/1999 Berns et al.
5,921,916 A 7/1999 Aeikens et al.
5,921,984 A 7/1999 Sutcu et al.
5,925,043 A 7/1999 Kumar et al.
5,928,136 A 7/1999 Barry
5,935,126 A 8/1999 Riza
5,938,589 A 8/1999 Wako et al.
5,941,869 A 8/1999 Patterson et al.
5,944,562 A 8/1999 Christensson
5,944,718 A 8/1999 Austin et al.
5,951,545 A 9/1999 Schilling et al.
5,951,546 A 9/1999 Lorentzen
5,951,549 A 9/1999 Richardson et al.
5,954,720 A 9/1999 Wilson et al.
5,954,731 A 9/1999 Yoon
5,954,733 A 9/1999 Yoon
5,957,923 A 9/1999 Hahnen et al.
5,957,937 A 9/1999 Yoon
5,960,544 A 10/1999 Beyers
5,961,514 A 10/1999 Long et al.
5,964,758 A 10/1999 Dresden
5,967,997 A 10/1999 Turturro et al.
D416,089 S 11/1999 Barton et al.
5,976,132 A 11/1999 Morris
5,984,932 A 11/1999 Yoon
5,984,938 A 11/1999 Yoon
5,984,939 A 11/1999 Yoon
5,989,277 A 11/1999 LeMaire, III et al.
5,993,466 A 11/1999 Yoon
5,993,467 A 11/1999 Yoon
5,993,474 A 11/1999 Ouchi
5,997,565 A 12/1999 Inoue
6,003,517 A 12/1999 Sheffield et al.
6,004,332 A 12/1999 Yoon et al.
6,004,335 A 12/1999 Vaitekunas et al.
6,010,516 A 1/2000 Hulka
6,010,519 A 1/2000 Mawhirt et al.
6,017,354 A 1/2000 Culp et al.
6,017,358 A 1/2000 Yoon et al.
6,021,693 A 2/2000 Feng-Sing
6,024,741 A 2/2000 Williamson, IV et al.
6,024,743 A 2/2000 Edwards
6,024,744 A 2/2000 Kese et al.
6,027,522 A 2/2000 Palmer
6,030,384 A 2/2000 Nezhat
6,033,399 A 3/2000 Gines
6,039,733 A 3/2000 Buysse et al.
6,041,679 A 3/2000 Slater et al.
6,050,995 A 4/2000 Durgin
6,050,996 A 4/2000 Schmaltz et al.
6,053,914 A 4/2000 Eggers et al.
6,053,933 A 4/2000 Balazs et al.
D424,694 S 5/2000 Tetzlaff et al.
D425,201 S 5/2000 Tetzlaff et al.
6,056,735 A 5/2000 Okada et al.
6,059,782 A 5/2000 Novak et al.
6,063,086 A 5/2000 Benecke et al.
6,063,103 A 5/2000 Hashiguchi
6,066,137 A 5/2000 Greep
6,066,139 A 5/2000 Ryan et al.
6,071,283 A 6/2000 Nardella et al.
6,074,386 A 6/2000 Goble et al.
6,077,287 A 6/2000 Taylor et al.
6,080,180 A 6/2000 Yoon et al.
RE36,795 E 7/2000 Rydell
6,083,150 A 7/2000 Aznoian et al.
6,083,223 A 7/2000 Baker
6,086,586 A * 7/2000 Hooven A61B 18/1442
606/48
6,086,601 A 7/2000 Yoon
6,090,107 A 7/2000 Borgmeier et al.
6,090,123 A 7/2000 Culp et al.
6,096,031 A 8/2000 Mitchell et al.
6,096,037 A 8/2000 Mulier et al.
6,099,537 A 8/2000 Sugai et al.
6,099,550 A 8/2000 Yoon
6,102,909 A 8/2000 Chen et al.
6,106,542 A 8/2000 Toybin et al.
6,110,171 A 8/2000 Rydell
6,113,596 A 9/2000 Hooven et al.
6,113,598 A 9/2000 Baker
6,117,158 A 9/2000 Measamer et al.
6,122,549 A 9/2000 Sharkey et al.
6,123,701 A 9/2000 Nezhat
H1904 H 10/2000 Yates et al.
6,126,658 A 10/2000 Baker
6,126,665 A 10/2000 Yoon
6,139,563 A 10/2000 Cosgrove, III et al.
6,143,005 A 11/2000 Yoon et al.
6,152,923 A 11/2000 Ryan
6,152,924 A 11/2000 Parins

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,159,217 A 12/2000 Robie et al.
6,162,220 A 12/2000 Nezhat
6,171,316 B1 1/2001 Kovac et al.
6,174,309 B1 1/2001 Wrublewski et al.
6,174,310 B1 1/2001 Kirwan, Jr.
6,178,628 B1 1/2001 Clemens et al.
6,179,834 B1 1/2001 Buysse et al.
6,179,837 B1 1/2001 Hooven
6,183,467 B1 2/2001 Shapeton et al.
6,187,003 B1 2/2001 Buysse et al.
6,190,386 B1 2/2001 Rydell
6,190,399 B1 2/2001 Palmer et al.
6,190,400 B1 2/2001 Van De Moer et al.
6,193,709 B1 2/2001 Miyawaki et al.
6,193,718 B1 2/2001 Kortenbach et al.
6,206,876 B1 3/2001 Levine et al.
6,206,877 B1 3/2001 Kese et al.
6,206,893 B1 3/2001 Klein et al.
6,214,028 B1 4/2001 Yoon et al.
6,217,602 B1 4/2001 Redmon
6,217,615 B1 4/2001 Sioshansi et al.
6,221,039 B1 4/2001 Durgin et al.
6,223,100 B1 4/2001 Green
6,224,593 B1 5/2001 Ryan et al.
6,224,614 B1 5/2001 Yoon
6,228,080 B1 5/2001 Gines
6,228,083 B1 5/2001 Lands et al.
6,248,124 B1 6/2001 Pedros et al.
6,248,944 B1 6/2001 Ito
6,249,706 B1 6/2001 Sobota et al.
6,261,307 B1 7/2001 Yoon et al.
6,267,758 B1 7/2001 Daw et al.
6,267,761 B1 7/2001 Ryan
6,270,497 B1 8/2001 Sekino et al.
6,270,508 B1 8/2001 Klieman et al.
6,273,887 B1 8/2001 Yamauchi et al.
6,277,117 B1 8/2001 Tetzlaff et al.
6,280,458 B1 8/2001 Boche et al.
6,283,961 B1 9/2001 Underwood et al.
D449,886 S 10/2001 Tetzlaff et al.
6,298,550 B1 10/2001 Kirwan, Jr.
6,302,424 B1 10/2001 Gisinger et al.
6,303,166 B1 10/2001 Kolbe et al.
6,309,404 B1 10/2001 Krzyzanowski
6,319,262 B1 11/2001 Bates et al.
6,319,451 B1 11/2001 Brune
6,322,561 B1 11/2001 Eggers et al.
6,322,580 B1 11/2001 Kanner
6,325,795 B1 12/2001 Lindemann et al.
6,329,778 B1 12/2001 Culp et al.
6,334,860 B1 1/2002 Dorn
6,334,861 B1 1/2002 Chandler et al.
D453,923 S 2/2002 Olson
6,345,532 B1 2/2002 Coudray et al.
6,350,264 B1 2/2002 Hooven
D454,951 S 3/2002 Bon
6,352,536 B1 3/2002 Buysse et al.
6,358,249 B1 3/2002 Chen et al.
6,358,259 B1 3/2002 Swain et al.
6,358,268 B1 3/2002 Hunt et al.
6,361,534 B1 3/2002 Chen et al.
6,364,876 B1 4/2002 Erb et al.
6,364,879 B1 4/2002 Chen et al.
D457,958 S 5/2002 Dycus et al.
D457,959 S 5/2002 Tetzlaff et al.
6,385,265 B1 5/2002 Duffy et al.
6,387,094 B1 5/2002 Eitenmuller
6,391,035 B1 5/2002 Appleby et al.
6,398,779 B1 6/2002 Buysse et al.
6,402,747 B1 6/2002 Lindemann et al.
6,409,728 B1 6/2002 Ehr et al.
H2037 H 7/2002 Yates et al.
6,419,675 B1 7/2002 Gallo, Sr.
6,425,896 B1 7/2002 Baltschun et al.
6,432,112 B2 8/2002 Brock et al.
6,440,130 B1 8/2002 Mulier et al.
6,440,144 B1 8/2002 Bacher
6,443,952 B1 9/2002 Mulier et al.
6,443,970 B1 9/2002 Schulze et al.
6,451,018 B1 9/2002 Lands et al.
6,458,125 B1 10/2002 Cosmescu
6,458,128 B1 10/2002 Schulze
6,458,129 B2 10/2002 Scarti
6,458,130 B1 10/2002 Frazier et al.
6,461,352 B2 10/2002 Morgan et al.
6,461,368 B2 10/2002 Fogarty et al.
6,464,701 B1 10/2002 Hooven et al.
6,464,702 B2 10/2002 Schulze et al.
6,464,704 B2 10/2002 Schmaltz et al.
6,471,696 B1 10/2002 Berube et al.
D465,281 S 11/2002 Lang
D466,209 S 11/2002 Bon
6,485,489 B2 11/2002 Teirstein et al.
6,488,680 B1 12/2002 Francischelli et al.
6,494,882 B1 12/2002 Lebouitz et al.
6,494,888 B1 12/2002 Laufer et al.
6,500,176 B1 12/2002 Truckai et al.
6,503,248 B1 1/2003 Levine
6,506,189 B1 1/2003 Rittman, III et al.
6,506,196 B1 1/2003 Laufer
6,508,815 B1 1/2003 Strul et al.
6,511,480 B1 1/2003 Tetzlaff et al.
6,514,215 B1 2/2003 Ouchi
6,514,251 B1 2/2003 Ni et al.
6,514,252 B2 2/2003 Nezhat et al.
6,517,536 B2 2/2003 Hooven et al.
6,517,539 B1 2/2003 Smith et al.
6,527,771 B1 3/2003 Weadock et al.
6,533,784 B2 3/2003 Truckai et al.
6,537,272 B2 3/2003 Christopherson et al.
6,540,745 B1 4/2003 Fairbourn et al.
6,544,264 B2 4/2003 Levine et al.
6,545,239 B2 4/2003 Spedale et al.
6,554,829 B2 4/2003 Schulze et al.
6,554,844 B2 4/2003 Lee et al.
6,558,385 B1 5/2003 McClurken et al.
6,562,037 B2 5/2003 Paton et al.
6,569,105 B1 5/2003 Kortenbach et al.
6,569,162 B2 5/2003 He
6,582,450 B2 6/2003 Ouchi
6,585,735 B1 7/2003 Frazier et al.
6,602,252 B2 8/2003 Mollenauer
6,605,790 B2 8/2003 Yoshida
6,610,060 B2 8/2003 Mulier et al.
6,613,048 B2 9/2003 Mulier et al.
6,616,654 B2 9/2003 Mollenauer
6,616,658 B2 9/2003 Ineson
6,616,661 B2 9/2003 Wellman et al.
6,620,161 B2 9/2003 Schulze et al.
6,620,184 B2 9/2003 de Laforcade et al.
6,623,482 B2 9/2003 Pendekanti et al.
6,626,901 B1 9/2003 Treat et al.
6,626,929 B1 9/2003 Bannerman
6,629,534 B1 10/2003 St. Goar et al.
6,638,287 B2 10/2003 Danitz et al.
6,641,595 B1 11/2003 Moran et al.
6,652,514 B2 11/2003 Ellman et al.
6,652,518 B2 11/2003 Wellman et al.
6,652,521 B2 11/2003 Schulze
6,656,173 B1 12/2003 Palermo
6,656,175 B2 12/2003 Francischelli et al.
6,656,177 B2 12/2003 Truckai et al.
6,660,072 B2 12/2003 Chatterjee
6,663,639 B1 12/2003 Laufer et al.
6,663,641 B1 12/2003 Kovac et al.
6,666,854 B1 12/2003 Lange
6,666,862 B2 12/2003 Jain et al.
6,669,696 B2 12/2003 Bacher et al.
6,673,092 B1 1/2004 Bacher
6,676,660 B2 1/2004 Wampler et al.
6,676,676 B2 1/2004 Danitz et al.
6,679,882 B1 1/2004 Komerup
6,682,527 B2 1/2004 Strul
6,682,528 B2 1/2004 Frazier et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,685,704 B2 2/2004 Greep
6,685,724 B1 2/2004 Haluck
6,689,131 B2 2/2004 McClurken
6,692,445 B2 2/2004 Roberts et al.
6,693,246 B1 2/2004 Rudolph et al.
6,695,840 B2 2/2004 Schulze
6,702,810 B2 3/2004 McClurken et al.
6,709,445 B2 3/2004 Boebel et al.
6,723,092 B2 4/2004 Brown et al.
6,726,068 B2 4/2004 Miller
6,726,686 B2 4/2004 Buysse et al.
6,726,694 B2 4/2004 Blatter et al.
6,733,498 B2 5/2004 Paton et al.
6,733,501 B2 5/2004 Levine
6,736,813 B2 5/2004 Yamauchi et al.
6,743,229 B2 6/2004 Buysse et al.
6,743,230 B2 6/2004 Lutze et al.
6,743,239 B1 6/2004 Kuehn et al.
6,743,240 B2 6/2004 Smith et al.
6,755,338 B2 6/2004 Hahnen et al.
6,755,824 B2 6/2004 Jain et al.
6,755,843 B2 6/2004 Chung et al.
6,756,553 B1 6/2004 Yamaguchi et al.
6,757,977 B2 7/2004 Dambal et al.
6,758,846 B2 7/2004 Goble et al.
D493,888 S 8/2004 Reschke
6,770,072 B1 8/2004 Truckai et al.
6,773,409 B2 8/2004 Truckai et al.
6,773,432 B1 8/2004 Clayman et al.
6,773,434 B2 8/2004 Ciarrocca
6,773,435 B2 8/2004 Schulze et al.
6,773,441 B1 8/2004 Laufer et al.
6,775,575 B2 8/2004 Bommannan et al.
6,776,780 B2 8/2004 Mulier et al.
6,780,181 B2 8/2004 Kroll et al.
6,784,405 B2 8/2004 Flugstad et al.
6,786,905 B2 9/2004 Swanson et al.
6,790,217 B2 9/2004 Schulze et al.
6,796,981 B2 9/2004 Wham et al.
D496,997 S 10/2004 Dycus et al.
6,800,825 B1 10/2004 Sasaki et al.
6,802,843 B2 10/2004 Truckai et al.
6,808,525 B2 10/2004 Latterell et al.
D499,181 S 11/2004 Dycus et al.
6,818,000 B2 11/2004 Muller et al.
6,818,007 B1 11/2004 Dampney et al.
6,821,273 B2 11/2004 Mollenauer
6,821,285 B2 11/2004 Laufer et al.
6,824,547 B2 11/2004 Wilson, Jr. et al.
6,830,174 B2 12/2004 Hillstead et al.
6,835,200 B2 12/2004 Laufer et al.
6,843,789 B2 1/2005 Goble
6,857,357 B2 2/2005 Fujii
6,858,028 B2 2/2005 Mulier et al.
D502,994 S 3/2005 Blake, III
6,860,880 B2 3/2005 Treat et al.
6,878,147 B2 4/2005 Prakash et al.
6,887,240 B1 5/2005 Lands et al.
6,889,116 B2 5/2005 Jinno
6,905,497 B2 6/2005 Truckai et al.
6,908,463 B2 6/2005 Treat et al.
6,914,201 B2 7/2005 Van Vooren et al.
6,926,716 B2 8/2005 Baker et al.
6,929,644 B2 8/2005 Truckai et al.
6,932,810 B2 8/2005 Ryan
6,932,816 B2 8/2005 Phan
6,934,134 B2 8/2005 Mori et al.
6,936,061 B2 8/2005 Sasaki
D509,297 S 9/2005 Wells
6,942,662 B2 9/2005 Goble et al.
6,943,311 B2 9/2005 Miyako
6,951,559 B1 10/2005 Greep
6,953,430 B2 10/2005 Kidooka
6,953,461 B2 10/2005 McClurken et al.
6,958,070 B2 10/2005 Witt et al.
6,960,210 B2 11/2005 Lands et al.
6,964,662 B2 11/2005 Kidooka
6,966,907 B2 11/2005 Goble
6,972,017 B2 12/2005 Smith et al.
6,974,452 B1 12/2005 Gille et al.
6,976,992 B2 12/2005 Sachatello et al.
6,977,495 B2 12/2005 Donofrio
6,979,786 B2 12/2005 Aukland et al.
6,981,628 B2 1/2006 Wales
6,987,244 B2 1/2006 Bauer
6,989,010 B2 1/2006 Francischelli et al.
6,989,017 B2 1/2006 Howell et al.
6,994,707 B2 2/2006 Ellman et al.
6,994,709 B2 2/2006 Iida
6,997,931 B2 2/2006 Sauer et al.
7,001,381 B2 2/2006 Harano et al.
7,001,408 B2 2/2006 Knodel et al.
7,011,657 B2 3/2006 Truckai et al.
7,025,763 B2 4/2006 Karasawa et al.
7,033,354 B2 4/2006 Keppel
7,033,356 B2 4/2006 Latterell et al.
7,041,102 B2 5/2006 Truckai et al.
7,044,948 B2 5/2006 Keppel
7,052,489 B2 5/2006 Griego et al.
7,052,496 B2 5/2006 Yamauchi
7,063,699 B2 6/2006 Hess et al.
7,063,715 B2 6/2006 Onuki et al.
D525,361 S 7/2006 Hushka
7,070,597 B2 7/2006 Truckai et al.
7,083,480 B2 8/2006 Silber
7,083,618 B2 8/2006 Couture et al.
7,083,619 B2 8/2006 Truckai et al.
7,083,620 B2 8/2006 Jahns et al.
7,087,051 B2 8/2006 Bourne et al.
7,087,054 B2 8/2006 Truckai et al.
7,090,673 B2 8/2006 Dycus et al.
7,090,689 B2 8/2006 Nagase et al.
7,101,371 B2 9/2006 Dycus et al.
7,101,372 B2 9/2006 Dycus et al.
7,101,373 B2 9/2006 Dycus et al.
7,103,947 B2 9/2006 Sartor et al.
7,107,124 B2 9/2006 Green
7,108,694 B2 9/2006 Miura et al.
7,112,199 B2 9/2006 Cosmescu
7,112,201 B2 9/2006 Truckai et al.
D531,311 S 10/2006 Guerra et al.
7,115,123 B2 10/2006 Knowlton et al.
7,115,139 B2 10/2006 McClurken et al.
7,118,570 B2 10/2006 Tetzlaff et al.
7,118,587 B2 10/2006 Dycus et al.
7,131,860 B2 11/2006 Sartor et al.
7,131,970 B2 11/2006 Moses et al.
7,131,971 B2 11/2006 Dycus et al.
7,135,018 B2 11/2006 Ryan et al.
7,135,020 B2 11/2006 Lawes et al.
7,137,980 B2 11/2006 Buysse et al.
D533,274 S 12/2006 Visconti et al.
D533,942 S 12/2006 Kerr et al.
7,145,757 B2 12/2006 Shea et al.
7,147,632 B2 12/2006 Prakash et al.
7,147,638 B2 12/2006 Chapman et al.
7,150,097 B2 12/2006 Sremcich et al.
7,150,749 B2 12/2006 Dycus et al.
7,153,314 B2 12/2006 Laufer et al.
D535,027 S 1/2007 James et al.
7,156,842 B2 1/2007 Sartor et al.
7,156,846 B2 1/2007 Dycus et al.
7,160,298 B2 1/2007 Lawes et al.
7,160,299 B2 1/2007 Baily
7,166,106 B2 1/2007 Bartel et al.
7,169,145 B2 1/2007 Isaacson et al.
7,169,146 B2 1/2007 Truckai et al.
7,179,255 B2 2/2007 Lettice et al.
7,179,258 B2 2/2007 Buysse et al.
7,184,820 B2 2/2007 Jersey-Willuhn et al.
D538,932 S 3/2007 Malik
7,189,233 B2 3/2007 Truckai et al.
7,195,631 B2 3/2007 Dumbauld
D541,418 S 4/2007 Schechter et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,204,832 B2 4/2007 Altshuler et al.
7,204,835 B2 4/2007 Latterell et al.
7,207,990 B2 4/2007 Lands et al.
7,208,005 B2 4/2007 Frecker et al.
D541,611 S 5/2007 Aglassinger
D541,938 S 5/2007 Kerr et al.
7,211,084 B2 5/2007 Goble et al.
7,223,264 B2 5/2007 Daniel et al.
7,223,265 B2 5/2007 Keppel
D545,432 S 6/2007 Watanabe
7,232,440 B2 6/2007 Dumbauld et al.
D547,154 S 7/2007 Lee
7,238,184 B2 7/2007 Megerman et al.
7,241,288 B2 7/2007 Braun
7,241,296 B2 7/2007 Buysse et al.
7,244,257 B2 7/2007 Podhajsky et al.
7,246,734 B2 7/2007 Shelton, IV
7,248,944 B2 7/2007 Green
7,252,667 B2 8/2007 Moses et al.
7,254,433 B2 8/2007 Diab et al.
7,255,697 B2 8/2007 Dycus et al.
7,258,688 B1 8/2007 Shah et al.
7,267,677 B2 9/2007 Johnson et al.
7,270,660 B2 9/2007 Ryan
7,270,664 B2 9/2007 Johnson et al.
7,276,068 B2 10/2007 Johnson et al.
7,288,103 B2 10/2007 Suzuki
7,291,161 B2 11/2007 Hooven
7,300,435 B2 11/2007 Wham et al.
7,303,557 B2 12/2007 Wham et al.
7,311,709 B2 12/2007 Truckai et al.
7,314,471 B2 1/2008 Holman
7,318,823 B2 1/2008 Sharps et al.
7,326,202 B2 2/2008 McGaffigan
7,329,256 B2 2/2008 Johnson et al.
7,329,257 B2 2/2008 Kanehira et al.
D564,662 S 3/2008 Moses et al.
7,338,526 B2 3/2008 Steinberg
7,342,754 B2 3/2008 Fitzgerald et al.
7,344,268 B2 3/2008 Jigamian
7,347,864 B2 3/2008 Vargas
D567,943 S 4/2008 Moses et al.
7,354,440 B2 4/2008 Truckal et al.
7,361,172 B2 4/2008 Cimino
7,367,976 B2 5/2008 Lawes et al.
7,377,920 B2 5/2008 Buysse et al.
7,384,420 B2 6/2008 Dycus et al.
7,384,421 B2 6/2008 Hushka
7,396,265 B2 7/2008 Darley et al.
7,396,336 B2 7/2008 Orszulak et al.
7,396,356 B2 7/2008 Mollenauer
D575,395 S 8/2008 Hushka
D575,401 S 8/2008 Hixson et al.
7,422,592 B2 9/2008 Morley et al.
7,425,835 B2 9/2008 Eisele
7,431,721 B2 10/2008 Paton et al.
7,435,249 B2 10/2008 Buysse et al.
7,438,714 B2 10/2008 Phan
7,442,193 B2 10/2008 Shields et al.
7,442,194 B2 10/2008 Dumbauld et al.
7,445,621 B2 11/2008 Dumbauld et al.
D582,038 S 12/2008 Swoyer et al.
7,458,972 B2 12/2008 Keppel
7,473,253 B2 1/2009 Dycus et al.
7,481,810 B2 1/2009 Dumbauld et al.
7,487,780 B2 2/2009 Hooven
7,491,201 B2 2/2009 Shields et al.
7,491,202 B2 2/2009 Odom et al.
7,500,975 B2 3/2009 Cunningham et al.
7,503,474 B2 3/2009 Hillstead et al.
7,510,556 B2 3/2009 Nguyen et al.
7,513,898 B2 4/2009 Johnson et al.
7,517,351 B2 4/2009 Culp et al.
7,540,872 B2 6/2009 Schechter et al.
7,549,995 B2 6/2009 Schultz
7,553,312 B2 6/2009 Tetzlaff et al.
7,553,686 B2 6/2009 George et al.
7,569,626 B2 8/2009 Truckai
7,582,087 B2 9/2009 Tetzlaff et al.
7,588,565 B2 9/2009 Marchitto et al.
7,594,313 B2 9/2009 Prakash et al.
7,594,916 B2 9/2009 Weinberg
7,597,693 B2 10/2009 Garrison
7,621,910 B2 11/2009 Sugi
7,624,186 B2 11/2009 Tanida
7,625,370 B2 12/2009 Hart et al.
7,628,791 B2 12/2009 Garrison et al.
7,628,792 B2 12/2009 Guerra
7,637,409 B2 12/2009 Marczyk
7,641,653 B2 1/2010 Dalla Betta et al.
7,651,493 B2 1/2010 Arts et al.
7,651,494 B2 1/2010 McClurken et al.
7,655,004 B2 2/2010 Long
7,655,007 B2 2/2010 Baily
7,668,597 B2 2/2010 Engmark et al.
7,678,111 B2 3/2010 Mulier et al.
7,686,804 B2 3/2010 Johnson et al.
7,686,827 B2 3/2010 Hushka
7,708,735 B2 5/2010 Chapman et al.
7,717,115 B2 5/2010 Barrett et al.
7,717,904 B2 5/2010 Suzuki et al.
7,717,914 B2 5/2010 Kimura
7,717,915 B2 5/2010 Miyazawa
7,722,607 B2 5/2010 Dumbauld et al.
D617,900 S 6/2010 Kingsley et al.
D617,901 S 6/2010 Unger et al.
D617,902 S 6/2010 Twomey et al.
D617,903 S 6/2010 Unger et al.
D618,798 S 6/2010 Olson et al.
7,727,231 B2 6/2010 Swanson
7,731,717 B2 6/2010 Odom et al.
7,736,374 B2 6/2010 Vaughan et al.
7,744,615 B2 6/2010 Couture
7,749,217 B2 7/2010 Podhajsky
7,753,908 B2 7/2010 Swanson
7,753,909 B2 7/2010 Chapman et al.
D621,503 S 8/2010 Otten et al.
7,766,910 B2 8/2010 Hixson et al.
7,771,425 B2 8/2010 Dycus et al.
7,776,036 B2 8/2010 Schechter et al.
7,776,037 B2 8/2010 Odom
7,780,662 B2 8/2010 Bahney
7,789,878 B2 9/2010 Dumbauld et al.
7,799,026 B2 9/2010 Schechter et al.
7,799,028 B2 9/2010 Schechter et al.
7,806,892 B2 10/2010 Makin et al.
7,811,283 B2 10/2010 Moses et al.
7,819,872 B2 10/2010 Johnson et al.
D627,462 S 11/2010 Kingsley
D628,289 S 11/2010 Romero
D628,290 S 11/2010 Romero
7,828,798 B2 11/2010 Buysse et al.
7,832,408 B2 11/2010 Shelton, IV et al.
7,837,685 B2 11/2010 Weinberg et al.
7,839,674 B2 11/2010 Lowrey et al.
7,842,033 B2 11/2010 Isaacson et al.
7,846,158 B2 12/2010 Podhajsky
7,846,161 B2 12/2010 Dumbauld et al.
7,857,812 B2 12/2010 Dycus et al.
D630,324 S 1/2011 Reschke
7,877,852 B2 2/2011 Unger et al.
7,877,853 B2 2/2011 Unger et al.
7,879,035 B2 2/2011 Garrison et al.
7,887,535 B2 2/2011 Lands et al.
7,887,536 B2 2/2011 Johnson et al.
7,896,878 B2 3/2011 Johnson et al.
7,898,288 B2 3/2011 Wong
7,900,805 B2 3/2011 Shelton, IV et al.
7,901,400 B2 3/2011 Wham et al.
7,905,380 B2 3/2011 Shelton, IV et al.
7,905,881 B2 3/2011 Masuda et al.
7,909,820 B2 3/2011 Lipson et al.
7,909,823 B2 3/2011 Moses et al.
7,909,824 B2 3/2011 Masuda et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,918,848	B2	4/2011	Lau et al.
7,922,718	B2	4/2011	Moses et al.
7,922,742	B2	4/2011	Hillstead et al.
7,922,953	B2	4/2011	Guerra
7,931,649	B2	4/2011	Couture et al.
7,935,052	B2	5/2011	Dumbauld
7,945,332	B2	5/2011	Schechter
7,947,041	B2	5/2011	Tetzlaff et al.
7,949,407	B2	5/2011	Kaplan et al.
7,951,149	B2	5/2011	Carlton
7,951,150	B2	5/2011	Johnson et al.
7,955,326	B2	6/2011	Paul et al.
7,955,327	B2	6/2011	Sartor et al.
7,955,331	B2	6/2011	Truckai et al.
7,955,332	B2	6/2011	Arts et al.
7,967,839	B2	6/2011	Flock et al.
7,972,328	B2	7/2011	Wham et al.
7,972,331	B2	7/2011	Hafner
7,976,544	B2	7/2011	McClurken et al.
7,981,113	B2	7/2011	Truckai et al.
7,988,507	B2	8/2011	Darley et al.
7,998,095	B2	8/2011	McAuley
8,012,150	B2	9/2011	Wham et al.
8,016,827	B2	9/2011	Chojin
8,034,049	B2	10/2011	Odom et al.
D649,249	S	11/2011	Guerra
D649,643	S	11/2011	Allen, IV et al.
8,048,074	B2	11/2011	Masuda
8,070,746	B2	12/2011	Orton et al.
8,070,748	B2	12/2011	Hixson et al.
8,075,580	B2	12/2011	Makower
8,089,417	B2	1/2012	Popovic et al.
8,092,451	B2	1/2012	Schechter et al.
8,104,956	B2	1/2012	Blaha
8,112,871	B2	2/2012	Brandt et al.
8,114,122	B2	2/2012	Nau, Jr.
8,123,743	B2	2/2012	Arts et al.
8,128,624	B2	3/2012	Couture et al.
8,128,625	B2	3/2012	Odom
8,133,224	B2	3/2012	Geiselhart
8,133,254	B2	3/2012	Dumbauld et al.
8,142,425	B2	3/2012	Eggers
8,142,473	B2	3/2012	Cunningham
8,147,485	B2	4/2012	Wham et al.
8,147,489	B2	4/2012	Moses et al.
8,157,145	B2	4/2012	Shelton, IV et al.
8,161,977	B2	4/2012	Shelton, IV et al.
8,162,940	B2	4/2012	Johnson et al.
8,162,965	B2	4/2012	Reschke et al.
8,162,973	B2	4/2012	Cunningham
8,177,794	B2	5/2012	Cabrera et al.
8,181,649	B2	5/2012	Brunner
8,182,476	B2	5/2012	Julian et al.
8,187,273	B2	5/2012	Kerr et al.
D661,394	S	6/2012	Romero et al.
8,192,433	B2	6/2012	Johnson et al.
8,192,444	B2	6/2012	Dycus
8,197,479	B2	6/2012	Olson et al.
8,197,633	B2	6/2012	Guerra
8,207,651	B2	6/2012	Gilbert
8,211,105	B2	7/2012	Buysse et al.
8,215,182	B2	7/2012	Artale et al.
8,216,223	B2	7/2012	Wham et al.
8,221,416	B2	7/2012	Townsend
8,226,650	B2	7/2012	Kerr
8,235,992	B2	8/2012	Guerra et al.
8,235,993	B2	8/2012	Hushka et al.
8,236,025	B2	8/2012	Hushka et al.
8,241,282	B2	8/2012	Unger et al.
8,241,283	B2	8/2012	Guerra et al.
8,241,284	B2	8/2012	Dycus et al.
8,246,618	B2	8/2012	Bucciaglia et al.
8,251,994	B2	8/2012	McKenna et al.
8,251,996	B2	8/2012	Hushka et al.
8,257,352	B2	9/2012	Lawes et al.
8,257,387	B2	9/2012	Cunningham
8,282,634	B2	10/2012	Cunningham et al.
D670,808	S	11/2012	Moua et al.
8,303,582	B2	11/2012	Cunningham
8,317,787	B2	11/2012	Hanna
8,328,803	B2	12/2012	Regadas
8,333,765	B2	12/2012	Johnson et al.
8,382,792	B2	2/2013	Chojin
D680,220	S	4/2013	Rachlin
8,454,602	B2	6/2013	Kerr et al.
8,469,956	B2	6/2013	McKenna et al.
8,469,957	B2	6/2013	Roy
8,486,107	B2	7/2013	Hinton
8,512,371	B2	8/2013	Kerr et al.
8,523,898	B2	9/2013	Bucciaglia et al.
8,529,566	B2	9/2013	Kappus et al.
8,535,312	B2	9/2013	Horner
8,568,408	B2	10/2013	Townsend et al.
8,568,412	B2	10/2013	Brandt et al.
8,591,510	B2	11/2013	Allen, IV et al.
8,623,276	B2	1/2014	Schmaltz et al.
8,628,557	B2	1/2014	Collings et al.
8,632,539	B2	1/2014	Twomey et al.
8,632,564	B2	1/2014	Cunningham
8,636,761	B2	1/2014	Cunningham et al.
8,668,689	B2	3/2014	Dumbauld et al.
8,679,098	B2	3/2014	Hart
8,679,114	B2	3/2014	Chapman et al.
8,679,115	B2	3/2014	Reschke
8,679,140	B2	3/2014	Butcher
8,685,009	B2	4/2014	Chernov et al.
8,685,056	B2	4/2014	Evans et al.
8,696,667	B2	4/2014	Guerra et al.
8,702,737	B2	4/2014	Chojin et al.
8,702,749	B2	4/2014	Twomey
8,745,840	B2	6/2014	Hempstead et al.
8,747,413	B2	6/2014	Dycus
8,747,434	B2	6/2014	Larson et al.
8,752,264	B2	6/2014	Ackley et al.
8,756,785	B2	6/2014	Allen, IV et al.
8,764,748	B2	7/2014	Chojin
8,784,417	B2	7/2014	Hanna
8,795,274	B2	8/2014	Hanna
8,845,636	B2	9/2014	Allen, IV et al.
8,852,185	B2	10/2014	Twomey
8,864,753	B2	10/2014	Nau, Jr. et al.
8,864,795	B2	10/2014	Kerr et al.
8,887,373	B2	11/2014	Brandt et al.
8,888,771	B2	11/2014	Twomey
8,900,232	B2	12/2014	Ourada
8,920,461	B2	12/2014	Unger et al.
8,939,972	B2	1/2015	Twomey
8,961,513	B2	2/2015	Allen, IV et al.
8,961,514	B2	2/2015	Garrison
8,961,515	B2	2/2015	Twomey et al.
8,968,283	B2	3/2015	Kharin
8,968,298	B2	3/2015	Twomey
8,968,305	B2	3/2015	Dumbauld et al.
8,968,306	B2	3/2015	Unger
8,968,307	B2	3/2015	Evans et al.
8,968,308	B2	3/2015	Horner et al.
8,968,309	B2	3/2015	Roy et al.
8,968,310	B2	3/2015	Twomey et al.
8,968,311	B2	3/2015	Allen, IV et al.
8,968,314	B2	3/2015	Allen, IV
8,968,317	B2	3/2015	Evans et al.
8,968,360	B2	3/2015	Garrison et al.
9,011,435	B2	4/2015	Brandt et al.
9,023,035	B2	5/2015	Allen, IV et al.
9,024,237	B2	5/2015	Bonn
9,028,492	B2	5/2015	Kerr et al.
9,033,981	B2	5/2015	Olson et al.
9,034,009	B2	5/2015	Twomey et al.
9,039,691	B2	5/2015	Moua et al.
9,039,704	B2	5/2015	Joseph
9,039,732	B2	5/2015	Sims et al.
9,060,780	B2	6/2015	Twomey et al.
9,060,798	B2	6/2015	Harper et al.
9,113,882	B2	8/2015	Twomey et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,113,899	B2	8/2015	Garrison et al.
9,113,901	B2	8/2015	Allen, IV et al.
9,113,909	B2	8/2015	Twomey et al.
9,113,933	B2	8/2015	Chernova et al.
9,113,934	B2	8/2015	Chernov et al.
9,113,938	B2	8/2015	Kerr
9,192,427	B2	11/2015	Johnson et al.
9,375,254	B2	6/2016	Heard
9,603,652	B2	3/2017	Carlton et al.
10,265,121	B2	4/2019	Dycus et al.
2001/0037109	A1	11/2001	Yamauchi et al.
2002/0013583	A1	1/2002	Camran et al.
2002/0029036	A1	3/2002	Goble et al.
2002/0049442	A1	4/2002	Roberts et al.
2002/0099372	A1	7/2002	Schulze et al.
2002/0099373	A1	7/2002	Schulze et al.
2002/0107517	A1	8/2002	Witt et al.
2002/0111624	A1	8/2002	Witt et al.
2002/0165469	A1	11/2002	Murakami
2002/0188294	A1	12/2002	Couture et al.
2003/0014052	A1	1/2003	Buysse et al.
2003/0014053	A1	1/2003	Nguyen et al.
2003/0018331	A1	1/2003	Dycus et al.
2003/0018332	A1	1/2003	Schmaltz et al.
2003/0069570	A1	4/2003	Witzel et al.
2003/0069571	A1	4/2003	Treat et al.
2003/0078578	A1	4/2003	Truckai et al.
2003/0109875	A1	6/2003	Tetzlaff et al.
2003/0114851	A1	6/2003	Truckai et al.
2003/0130653	A1	7/2003	Sixto et al.
2003/0139741	A1	7/2003	Goble et al.
2003/0139742	A1	7/2003	Wampler et al.
2003/0158548	A1	8/2003	Phan et al.
2003/0158549	A1	8/2003	Swanson
2003/0171747	A1	9/2003	Kanehira et al.
2003/0181898	A1	9/2003	Bowers
2003/0181910	A1	9/2003	Dycus et al.
2003/0191396	A1	10/2003	Sanghvi et al.
2003/0199869	A1	10/2003	Johnson et al.
2003/0216732	A1	11/2003	Truckai et al.
2003/0220637	A1	11/2003	Truckai et al.
2003/0229344	A1	12/2003	Dycus et al.
2003/0236325	A1	12/2003	Bonora
2003/0236518	A1	12/2003	Marchitto et al.
2004/0030330	A1	2/2004	Brassell et al.
2004/0030332	A1	2/2004	Knowlton et al.
2004/0049185	A1	3/2004	Latterell et al.
2004/0064151	A1	4/2004	Mollenauer
2004/0073238	A1	4/2004	Makower
2004/0073256	A1	4/2004	Marchitto et al.
2004/0082952	A1	4/2004	Dycus et al.
2004/0087943	A1	5/2004	Dycus et al.
2004/0115296	A1	6/2004	Duffin
2004/0116979	A1	6/2004	Truckai et al.
2004/0122423	A1	6/2004	Dycus et al.
2004/0143263	A1	7/2004	Schechter et al.
2004/0147925	A1	7/2004	Buysse et al.
2004/0148035	A1	7/2004	Barrett et al.
2004/0162557	A1	8/2004	Tetzlaff et al.
2004/0176779	A1	9/2004	Casutt et al.
2004/0199181	A1	10/2004	Knodel et al.
2004/0210282	A1	10/2004	Flock et al.
2004/0224590	A1	11/2004	Rawa et al.
2004/0225288	A1	11/2004	Buysse et al.
2004/0230189	A1	11/2004	Keppel
2004/0236325	A1	11/2004	Tetzlaff et al.
2004/0236326	A1	11/2004	Schulze et al.
2004/0243125	A1	12/2004	Dycus et al.
2004/0249371	A1	12/2004	Dycus et al.
2004/0249374	A1	12/2004	Tetzlaff et al.
2004/0250419	A1	12/2004	Sremcich et al.
2004/0254573	A1	12/2004	Dycus et al.
2004/0260281	A1	12/2004	Baxter et al.
2005/0004564	A1	1/2005	Wham et al.
2005/0004568	A1	1/2005	Lawes et al.
2005/0004569	A1	1/2005	Witt et al.
2005/0004570	A1	1/2005	Chapman et al.
2005/0021025	A1	1/2005	Buysse et al.
2005/0021026	A1	1/2005	Baily
2005/0021027	A1	1/2005	Shields et al.
2005/0033278	A1	2/2005	McClurken et al.
2005/0059858	A1	3/2005	Frith et al.
2005/0059934	A1	3/2005	Wenchell et al.
2005/0090817	A1	4/2005	Phan
2005/0096645	A1	5/2005	Wellman et al.
2005/0101951	A1	5/2005	Wham et al.
2005/0101952	A1	5/2005	Lands et al.
2005/0107784	A1	5/2005	Moses et al.
2005/0107785	A1	5/2005	Dycus et al.
2005/0113818	A1	5/2005	Sartor et al.
2005/0113819	A1	5/2005	Wham et al.
2005/0113826	A1	5/2005	Johnson et al.
2005/0113827	A1	5/2005	Dumbauld et al.
2005/0113828	A1	5/2005	Shields et al.
2005/0119655	A1	6/2005	Moses et al.
2005/0149017	A1	7/2005	Dycus
2005/0149151	A1	7/2005	Orszulak et al.
2005/0154387	A1	7/2005	Moses et al.
2005/0187547	A1	8/2005	Sugi
2005/0197659	A1	9/2005	Bahney
2005/0203504	A1	9/2005	Wham et al.
2005/0222560	A1	10/2005	Kimura et al.
2005/0240179	A1	10/2005	Buysse et al.
2005/0254081	A1	11/2005	Ryu et al.
2005/0261588	A1	11/2005	Makin et al.
2005/0283148	A1	12/2005	Janssen et al.
2006/0052777	A1	3/2006	Dumbauld
2006/0052778	A1	3/2006	Chapman et al.
2006/0052779	A1	3/2006	Hammill
2006/0064085	A1	3/2006	Schechter et al.
2006/0064086	A1	3/2006	Odom
2006/0079888	A1	4/2006	Mulier et al.
2006/0079890	A1	4/2006	Guerra
2006/0079891	A1	4/2006	Arts et al.
2006/0079933	A1	4/2006	Hushka et al.
2006/0084973	A1	4/2006	Hushka
2006/0089670	A1	4/2006	Hushka
2006/0111711	A1	5/2006	Goble
2006/0116675	A1	6/2006	McClurken et al.
2006/0129146	A1	6/2006	Dycus et al.
2006/0161150	A1	7/2006	Keppel
2006/0167450	A1	7/2006	Johnson et al.
2006/0167452	A1	7/2006	Moses et al.
2006/0173452	A1	8/2006	Buysse et al.
2006/0189980	A1	8/2006	Johnson et al.
2006/0189981	A1	8/2006	Dycus et al.
2006/0190035	A1	8/2006	Hushka et al.
2006/0217709	A1	9/2006	Couture et al.
2006/0224053	A1	10/2006	Black et al.
2006/0224158	A1	10/2006	Odom et al.
2006/0229666	A1	10/2006	Suzuki et al.
2006/0253126	A1	11/2006	Bjerken et al.
2006/0259036	A1	11/2006	Tetzlaff et al.
2006/0264922	A1	11/2006	Sartor et al.
2006/0264931	A1	11/2006	Chapman et al.
2006/0271030	A1	11/2006	Francis et al.
2006/0271038	A1	11/2006	Johnson et al.
2006/0283093	A1	12/2006	Petrovic et al.
2006/0287641	A1	12/2006	Perlin
2007/0016182	A1	1/2007	Lipson et al.
2007/0016187	A1	1/2007	Weinberg et al.
2007/0027447	A1	2/2007	Theroux et al.
2007/0043352	A1	2/2007	Garrison et al.
2007/0043353	A1	2/2007	Dycus et al.
2007/0055231	A1	3/2007	Dycus et al.
2007/0060919	A1	3/2007	Isaacson et al.
2007/0062017	A1	3/2007	Dycus et al.
2007/0074807	A1	4/2007	Guerra
2007/0078456	A1	4/2007	Dumbauld et al.
2007/0078458	A1	4/2007	Dumbauld et al.
2007/0078459	A1	4/2007	Johnson et al.
2007/0088356	A1	4/2007	Moses et al.
2007/0106295	A1	5/2007	Garrison et al.
2007/0106297	A1	5/2007	Dumbauld et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2007/0118111	A1	5/2007	Weinberg
2007/0118115	A1	5/2007	Artale et al.
2007/0142833	A1	6/2007	Dycus et al.
2007/0142834	A1	6/2007	Dumbauld
2007/0156139	A1	7/2007	Schechter et al.
2007/0156140	A1	7/2007	Baily
2007/0173811	A1	7/2007	Couture et al.
2007/0173813	A1	7/2007	Odom
2007/0173814	A1	7/2007	Hixson et al.
2007/0179499	A1	8/2007	Garrison
2007/0198011	A1	8/2007	Sugita
2007/0203485	A1	8/2007	Keppel
2007/0213706	A1	9/2007	Dumbauld et al.
2007/0213707	A1	9/2007	Dumbauld et al.
2007/0213708	A1	9/2007	Dumbauld et al.
2007/0213712	A1	9/2007	Buysse et al.
2007/0225695	A1	9/2007	Mayer et al.
2007/0255279	A1	11/2007	Buysse et al.
2007/0260235	A1	11/2007	Podhajsky
2007/0260238	A1	11/2007	Guerra
2007/0260241	A1	11/2007	Dalla Betta et al.
2007/0260242	A1	11/2007	Dycus et al.
2007/0265616	A1	11/2007	Couture et al.
2007/0265620	A1	11/2007	Kraas et al.
2008/0004616	A1	1/2008	Patrick
2008/0009860	A1	1/2008	Odom
2008/0015563	A1	1/2008	Hoey et al.
2008/0015575	A1	1/2008	Odom et al.
2008/0021450	A1	1/2008	Couture
2008/0033428	A1	2/2008	Artale et al.
2008/0039835	A1	2/2008	Johnson et al.
2008/0039836	A1	2/2008	Odom et al.
2008/0045947	A1	2/2008	Johnson et al.
2008/0046122	A1	2/2008	Manzo et al.
2008/0058802	A1	3/2008	Couture et al.
2008/0082100	A1	4/2008	Orton et al.
2008/0091189	A1	4/2008	Carlton
2008/0125797	A1	5/2008	Kelleher
2008/0171938	A1	7/2008	Masuda et al.
2008/0172051	A1	7/2008	Masuda et al.
2008/0195093	A1	8/2008	Couture et al.
2008/0215050	A1	9/2008	Bakos
2008/0215051	A1	9/2008	Buysse et al.
2008/0234672	A1	9/2008	Bastian
2008/0234701	A1	9/2008	Morales et al.
2008/0243106	A1	10/2008	Coe et al.
2008/0243120	A1	10/2008	Lawes et al.
2008/0243158	A1	10/2008	Morgan
2008/0249523	A1	10/2008	McPherson et al.
2008/0249527	A1	10/2008	Couture
2008/0271360	A1	11/2008	Barfield
2008/0281311	A1	11/2008	Dunning et al.
2008/0312653	A1	12/2008	Arts et al.
2008/0319292	A1	12/2008	Say et al.
2008/0319442	A1	12/2008	Unger et al.
2009/0012520	A1	1/2009	Hixson et al.
2009/0012556	A1	1/2009	Boudreaux et al.
2009/0018535	A1	1/2009	Schechter et al.
2009/0024126	A1	1/2009	Artale et al.
2009/0036881	A1	2/2009	Artale et al.
2009/0036899	A1	2/2009	Carlton et al.
2009/0043304	A1	2/2009	Tetzlaff et al.
2009/0048596	A1	2/2009	Shields et al.
2009/0054894	A1	2/2009	Yachi
2009/0062794	A1	3/2009	Buysse et al.
2009/0065565	A1	3/2009	Cao
2009/0076506	A1	3/2009	Baker
2009/0082766	A1	3/2009	Unger et al.
2009/0082767	A1	3/2009	Unger et al.
2009/0082769	A1	3/2009	Unger et al.
2009/0088738	A1	4/2009	Guerra et al.
2009/0088739	A1	4/2009	Hushka et al.
2009/0088740	A1	4/2009	Guerra et al.
2009/0088741	A1	4/2009	Hushka et al.
2009/0088744	A1	4/2009	Townsend
2009/0088745	A1	4/2009	Hushka et al.
2009/0088746	A1	4/2009	Hushka et al.
2009/0088747	A1	4/2009	Hushka et al.
2009/0088748	A1	4/2009	Guerra et al.
2009/0088749	A1	4/2009	Hushka et al.
2009/0088750	A1	4/2009	Hushka et al.
2009/0105750	A1	4/2009	Price et al.
2009/0112206	A1	4/2009	Dumbauld et al.
2009/0112229	A1	4/2009	Omori et al.
2009/0131934	A1	5/2009	Odom et al.
2009/0138003	A1	5/2009	Deville et al.
2009/0138006	A1	5/2009	Bales et al.
2009/0149853	A1	6/2009	Shields et al.
2009/0149854	A1	6/2009	Cunningham et al.
2009/0157071	A1	6/2009	Wham et al.
2009/0171350	A1	7/2009	Dycus et al.
2009/0171353	A1	7/2009	Johnson et al.
2009/0171354	A1	7/2009	Deville et al.
2009/0177094	A1	7/2009	Brown et al.
2009/0182327	A1	7/2009	Unger
2009/0187188	A1	7/2009	Guerra et al.
2009/0198233	A1	8/2009	Chojin
2009/0204114	A1	8/2009	Odom
2009/0204137	A1	8/2009	Maxwell
2009/0206126	A1	8/2009	Huitema et al.
2009/0209957	A1	8/2009	Schmaltz et al.
2009/0209960	A1	8/2009	Chojin
2009/0234354	A1	9/2009	Johnson et al.
2009/0248007	A1	10/2009	Falkenstein et al.
2009/0248013	A1	10/2009	Falkenstein et al.
2009/0248019	A1	10/2009	Falkenstein et al.
2009/0248020	A1	10/2009	Falkenstein et al.
2009/0248021	A1	10/2009	McKenna
2009/0248022	A1	10/2009	Falkenstein et al.
2009/0248050	A1	10/2009	Hirai
2009/0254080	A1	10/2009	Honda
2009/0254081	A1	10/2009	Allison et al.
2009/0261804	A1	10/2009	McKenna et al.
2009/0270771	A1	10/2009	Takahashi
2009/0275865	A1	11/2009	Zhao et al.
2009/0292282	A9	11/2009	Dycus
2009/0299364	A1	12/2009	Batchelor et al.
2009/0312273	A1	12/2009	De La Torre
2009/0318912	A1	12/2009	Mayer et al.
2010/0016857	A1	1/2010	McKenna et al.
2010/0023009	A1	1/2010	Moses et al.
2010/0036375	A1	2/2010	Regadas
2010/0042143	A1	2/2010	Cunningham
2010/0049187	A1	2/2010	Carlton et al.
2010/0049194	A1	2/2010	Hart et al.
2010/0057078	A1	3/2010	Arts et al.
2010/0057081	A1	3/2010	Hanna
2010/0057082	A1	3/2010	Hanna
2010/0057083	A1	3/2010	Hanna
2010/0057084	A1	3/2010	Hanna
2010/0063500	A1	3/2010	Muszala
2010/0069903	A1	3/2010	Allen, IV et al.
2010/0069904	A1	3/2010	Cunningham
2010/0069953	A1	3/2010	Cunningham et al.
2010/0076427	A1	3/2010	Heard
2010/0076430	A1	3/2010	Romero
2010/0076431	A1	3/2010	Allen, IV
2010/0087816	A1	4/2010	Roy
2010/0094271	A1	4/2010	Ward et al.
2010/0094287	A1	4/2010	Cunningham et al.
2010/0094289	A1	4/2010	Taylor et al.
2010/0100122	A1	4/2010	Hinton
2010/0130971	A1	5/2010	Baily
2010/0130977	A1	5/2010	Garrison et al.
2010/0168741	A1	7/2010	Sanai et al.
2010/0179543	A1	7/2010	Johnson et al.
2010/0179545	A1	7/2010	Twomey et al.
2010/0179546	A1	7/2010	Cunningham
2010/0179547	A1	7/2010	Cunningham et al.
2010/0198218	A1	8/2010	Manzo
2010/0198248	A1	8/2010	Vakharia
2010/0204697	A1	8/2010	Dumbauld et al.
2010/0217258	A1	8/2010	Floume et al.
2010/0217264	A1	8/2010	Odom et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0228249 A1 9/2010 Mohr et al.
2010/0228250 A1 9/2010 Brogna
2010/0249769 A1 9/2010 Nau, Jr. et al.
2010/0274160 A1 10/2010 Yachi et al.
2010/0274244 A1 10/2010 Heard
2010/0274265 A1 10/2010 Wingardner et al.
2010/0280511 A1 11/2010 Rachlin et al.
2010/0292691 A1 11/2010 Brogna
2010/0305558 A1 12/2010 Kimura et al.
2010/0307934 A1 12/2010 Chowaniec et al.
2010/0312235 A1 12/2010 Bahney
2010/0331742 A1 12/2010 Masuda
2010/0331839 A1 12/2010 Schechter et al.
2011/0004210 A1 1/2011 Johnson et al.
2011/0015632 A1 1/2011 Artale
2011/0018164 A1 1/2011 Sartor et al.
2011/0034918 A1 2/2011 Reschke
2011/0054467 A1 3/2011 Mueller et al.
2011/0054468 A1 3/2011 Dycus
2011/0054469 A1 3/2011 Kappus et al.
2011/0054471 A1 3/2011 Gerhardt et al.
2011/0054472 A1 3/2011 Romero
2011/0060333 A1 3/2011 Mueller
2011/0060335 A1 3/2011 Harper et al.
2011/0071523 A1 3/2011 Dickhans
2011/0071525 A1 3/2011 Dumbauld et al.
2011/0072638 A1 3/2011 Brandt et al.
2011/0077637 A1 3/2011 Brannan
2011/0077648 A1 3/2011 Lee et al.
2011/0077649 A1 3/2011 Kingsley
2011/0082457 A1 4/2011 Kerr et al.
2011/0087221 A1 4/2011 Siebrecht et al.
2011/0098689 A1 4/2011 Nau, Jr. et al.
2011/0106079 A1 5/2011 Garrison et al.
2011/0178519 A1 7/2011 Couture et al.
2011/0184405 A1 7/2011 Mueller
2011/0190653 A1 8/2011 Harper et al.
2011/0190765 A1 8/2011 Chojin
2011/0193608 A1 8/2011 Krapohl
2011/0218530 A1 9/2011 Reschke
2011/0230880 A1 9/2011 Chojin et al.
2011/0238066 A1 9/2011 Olson
2011/0238067 A1 9/2011 Moses et al.
2011/0251605 A1 10/2011 Hoarau et al.
2011/0251606 A1 10/2011 Kerr
2011/0251611 A1 10/2011 Horner et al.
2011/0257680 A1 10/2011 Reschke et al.
2011/0257681 A1 10/2011 Reschke et al.
2011/0270245 A1 11/2011 Horner et al.
2011/0270250 A1 11/2011 Horner et al.
2011/0270251 A1 11/2011 Horner et al.
2011/0270252 A1 11/2011 Horner et al.
2011/0275901 A1 11/2011 Shelton, IV
2011/0276048 A1 11/2011 Kerr et al.
2011/0276049 A1 11/2011 Gerhardt
2011/0295251 A1 12/2011 Garrison
2011/0295313 A1 12/2011 Kerr
2011/0301592 A1 12/2011 Kerr et al.
2011/0301599 A1 12/2011 Roy et al.
2011/0301600 A1 12/2011 Garrison et al.
2011/0301601 A1 12/2011 Garrison et al.
2011/0301602 A1 12/2011 Roy et al.
2011/0301603 A1 12/2011 Kerr et al.
2011/0301604 A1 12/2011 Horner et al.
2011/0301605 A1 12/2011 Horner
2011/0301606 A1 12/2011 Kerr
2011/0301637 A1 12/2011 Kerr et al.
2011/0319886 A1 12/2011 Chojin et al.
2011/0319888 A1 12/2011 Mueller et al.
2012/0004658 A1 1/2012 Chojin
2012/0010614 A1 1/2012 Couture
2012/0022532 A1 1/2012 Garrison
2012/0029515 A1 2/2012 Couture
2012/0041438 A1 2/2012 Nau, Jr. et al.
2012/0046659 A1 2/2012 Mueller
2012/0046660 A1 2/2012 Nau, Jr.
2012/0046662 A1 2/2012 Gilbert
2012/0059371 A1 3/2012 Anderson et al.
2012/0059372 A1 3/2012 Johnson
2012/0059374 A1 3/2012 Johnson et al.
2012/0059375 A1 3/2012 Couture et al.
2012/0059408 A1 3/2012 Mueller
2012/0059409 A1 3/2012 Reschke et al.
2012/0078250 A1 3/2012 Orton et al.
2012/0083785 A1 4/2012 Roy et al.
2012/0083786 A1 4/2012 Artale et al.
2012/0083827 A1 4/2012 Artale et al.
2012/0095456 A1 4/2012 Schechter et al.
2012/0095460 A1 4/2012 Rooks et al.
2012/0109187 A1 5/2012 Gerhardt, Jr. et al.
2012/0118507 A1 5/2012 Brandt et al.
2012/0123402 A1 5/2012 Chernov et al.
2012/0123404 A1 5/2012 Craig
2012/0123410 A1 5/2012 Craig
2012/0123413 A1 5/2012 Chernov et al.
2012/0130367 A1 5/2012 Garrison
2012/0136353 A1 5/2012 Romero
2012/0136354 A1 5/2012 Rupp
2012/0143185 A1 6/2012 Nau, Jr.
2012/0165797 A1 6/2012 Cunningham
2012/0165818 A1 6/2012 Odom
2012/0172868 A1 7/2012 Twomey et al.
2012/0172873 A1 7/2012 Artale et al.
2012/0172924 A1 7/2012 Allen, IV
2012/0172925 A1 7/2012 Dumbauld et al.
2012/0184989 A1 7/2012 Twomey
2012/0184990 A1 7/2012 Twomey
2012/0202179 A1 8/2012 Fedotov et al.
2012/0209263 A1 8/2012 Sharp et al.
2012/0215219 A1 8/2012 Roy et al.
2012/0215242 A1 8/2012 Reschke et al.
2012/0239034 A1 9/2012 Horner et al.
2012/0259331 A1 10/2012 Garrison
2012/0265241 A1 10/2012 Hart et al.
2012/0296205 A1 11/2012 Chernov et al.
2012/0296238 A1 11/2012 Chernov et al.
2012/0296239 A1 11/2012 Chernov et al.
2012/0296323 A1 11/2012 Chernov et al.
2012/0296371 A1 11/2012 Kappus et al.
2012/0303025 A1 11/2012 Garrison
2012/0303026 A1 11/2012 Dycus et al.
2012/0323238 A1 12/2012 Tyrrell et al.
2012/0330308 A1 12/2012 Joseph
2013/0018364 A1 1/2013 Chernov et al.
2013/0022495 A1 1/2013 Allen, IV et al.
2013/0071282 A1 3/2013 Fry
2013/0072927 A1 3/2013 Allen, IV et al.
2013/0079760 A1 3/2013 Twomey et al.
2013/0079774 A1 3/2013 Whitney et al.
2013/0085496 A1 4/2013 Unger et al.
2013/0103030 A1 4/2013 Garrison
2013/0103031 A1 4/2013 Garrison
2013/0138101 A1 5/2013 Kerr
2013/0144284 A1 6/2013 Behnke, II et al.
2013/0197503 A1 8/2013 Orszulak
2013/0253489 A1 9/2013 Nau, Jr. et al.
2013/0255063 A1 10/2013 Hart et al.
2013/0274736 A1 10/2013 Garrison
2013/0289561 A1 10/2013 Waaler et al.
2013/0296922 A1 11/2013 Allen, IV et al.
2013/0304058 A1 11/2013 Kendrick
2013/0304066 A1 11/2013 Kerr et al.
2013/0325057 A1 12/2013 Larson et al.
2015/0011930 A1* 1/2015 Yamanishi A61B 18/12
604/23
2015/0250532 A1 9/2015 Dycus et al.
2015/0257819 A1 9/2015 Dycus et al.
2017/0042607 A1 2/2017 Dycus et al.

FOREIGN PATENT DOCUMENTS

CA 2590520 A1 11/2007
CN 201299462 Y 9/2009
DE 2415263 A1 10/1975

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

DE	02514501	A1	10/1976
DE	2627679	A1	1/1977
DE	03423356	A1	1/1986
DE	03612646	A1	4/1987
DE	3627221	A1	2/1988
DE	8712328	U1	2/1988
DE	04303882	C2	2/1995
DE	04403252	A1	8/1995
DE	19515914	C1	7/1996
DE	19506363	A1	8/1996
DE	29616210	U1	11/1996
DE	19608716	C1	4/1997
DE	19751106	A1	5/1998
DE	19738457	A1	3/1999
DE	19751108	A1	5/1999
DE	19946527	C1	7/2001
DE	10031773	A1	11/2001
DE	10045375	A1	4/2002
DE	20121161	U1	4/2002
DE	202007009165	U1	8/2007
DE	202007009317	U1	8/2007
DE	202007009318	U1	8/2007
DE	202007016233	U1	1/2008
DE	102004026179	B4	1/2009
DE	102008018406	B3	7/2009
EP	0364216	A1	4/1990
EP	0467501	A1	1/1992
EP	0509670	A3	12/1992
EP	0518230	A1	12/1992
EP	0306123	B1	8/1993
EP	0572131	A1	12/1993
EP	0584787	A1	3/1994
EP	0589555	A1	3/1994
EP	0589453	A3	4/1994
EP	0648475	A1	4/1995
EP	0624348	A3	6/1995
EP	0517243	B1	9/1997
EP	0541930	B1	3/1998
EP	0853922	A1	7/1998
EP	0878169	A1	11/1998
EP	0623316	B1	3/1999
EP	0650701	B1	3/1999
EP	0923907	A1	6/1999
EP	0640317	B1	9/1999
EP	0986990	A1	3/2000
EP	1034747	A1	9/2000
EP	1034748	A1	9/2000
EP	0694290	B1	11/2000
EP	1050278	A1	11/2000
EP	1053719	A1	11/2000
EP	1053720	A1	11/2000
EP	1055399	A1	11/2000
EP	1055400	A1	11/2000
EP	1080694	A1	3/2001
EP	1082944	A1	3/2001
EP	1177771	A1	2/2002
EP	1281878	A1	2/2003
EP	1159926	A2	3/2003
EP	0717966	B1	4/2003
EP	1301135	A1	4/2003
EP	0887046	B1	7/2003
EP	1330991	A1	7/2003
EP	1472984	A1	11/2004
EP	0754437	B2	12/2004
EP	1025807	B1	12/2004
EP	1486177	A2	12/2004
EP	0774232	B1	1/2005
EP	1527747	A2	5/2005
EP	1530952	A1	5/2005
EP	1532932	A1	5/2005
EP	1535581	A2	6/2005
EP	1609430	A1	12/2005
EP	1034746	B1	3/2006
EP	1632192	A1	3/2006
EP	1642543	A1	4/2006
EP	1645238	A1	4/2006
EP	1645240	A2	4/2006
EP	1649821	A1	4/2006
EP	0875209	B1	5/2006
EP	1683496	A2	7/2006
EP	1707143	A1	10/2006
EP	1769765	A1	4/2007
EP	1769766	A1	4/2007
EP	1929970	A1	6/2008
EP	1946715	A1	7/2008
EP	2382936	A1	11/2011
GB	623316	A	5/1949
GB	1490585	A	11/1977
GB	2213416	A	8/1989
GB	2214430	A	9/1989
JP	61501068	A	5/1986
JP	1024051		1/1989
JP	1147150		6/1989
JP	H055106	A	1/1993
JP	H0540112	A	2/1993
JP	6121797		5/1994
JP	6285078	A	10/1994
JP	6511401	A	12/1994
JP	H06343644	A	12/1994
JP	H07265328	A	10/1995
JP	H0856955	A	3/1996
JP	08252263	A	10/1996
JP	8289895	A	11/1996
JP	8317934	A	12/1996
JP	8317936	A	12/1996
JP	09000538	A	1/1997
JP	H0910223	A	1/1997
JP	9122138	A	5/1997
JP	0010000195	A	1/1998
JP	10155798	A	6/1998
JP	1147149		2/1999
JP	11070124	A	3/1999
JP	11169381	A	6/1999
JP	11192238	A	7/1999
JP	H11244298	A	9/1999
JP	2000102545	A	4/2000
JP	2000135222	A	5/2000
JP	2000342599	A	12/2000
JP	2000350732	A	12/2000
JP	2001003400	A	1/2001
JP	2001008944		1/2001
JP	2001029355		2/2001
JP	2001029356		2/2001
JP	2001128990	A	5/2001
JP	2001190564	A	7/2001
JP	2002136525	A	5/2002
JP	2002528166	A	9/2002
JP	2003116871	A	4/2003
JP	2003175052	A	6/2003
JP	2003245285	A	9/2003
JP	2004517668	A	6/2004
JP	2004528869	A	9/2004
JP	2004532676	A	10/2004
JP	2005152663	A	6/2005
JP	2005523380	A	8/2005
JP	2005253789	A	9/2005
JP	2005312807	A	11/2005
JP	2006015078	A	1/2006
JP	2006501939	A	1/2006
JP	2006095316	A	4/2006
JP	2007098139	A	4/2007
JP	2008054926	A	3/2008
JP	2011125195	A	6/2011
JP	000603945	B2	11/2016
JP	6502328	B2	4/2019
SU	401367	A1	10/1973
WO	8900757	A1	1/1989
WO	9204873	A1	4/1992
WO	9206642	A1	4/1992
WO	9321845	A1	11/1993
WO	9408524	A1	4/1994
WO	9420025	A1	9/1994
WO	9502369	A1	1/1995
WO	9507662	A1	3/1995

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	9515124	A1	6/1995
WO	9605776	A1	2/1996
WO	9613218	A1	5/1996
WO	9622056	A1	7/1996
WO	9700646	A1	1/1997
WO	9700647	A1	1/1997
WO	9710764	A1	3/1997
WO	9724073	A1	7/1997
WO	9724993	A1	7/1997
WO	9827880	A1	7/1998
WO	9903407	A1	1/1999
WO	9903408	A1	1/1999
WO	9903409	A1	1/1999
WO	9912488	A1	3/1999
WO	9923933	A2	5/1999
WO	9940857	A1	8/1999
WO	9940861	A1	8/1999
WO	9951158	A1	10/1999
WO	9966850	A1	12/1999
WO	0024330	A1	5/2000
WO	0024331	A1	5/2000
WO	0036986	A1	6/2000
WO	0041638	A1	7/2000
WO	0047124	A1	8/2000
WO	0053112	A2	9/2000
WO	0059392	A1	10/2000
WO	0115614	A1	3/2001
WO	0117448	A2	3/2001
WO	0154604	A1	8/2001
WO	0207627		1/2002
WO	0245589	A2	6/2002
WO	02067798	A1	9/2002
WO	02080783	A1	10/2002
WO	02080784	A1	10/2002
WO	02080785	A1	10/2002
WO	02080786	A1	10/2002
WO	02080793	A1	10/2002
WO	02080794	A1	10/2002
WO	02080795	A1	10/2002
WO	02080796	A1	10/2002
WO	02080797	A1	10/2002
WO	02080798	A1	10/2002
WO	02080799	A1	10/2002
WO	02081170	A1	10/2002
WO	02085218	A1	10/2002
WO	02094746	A1	11/2002
WO	03061500	A2	7/2003
WO	2003055449	A1	7/2003
WO	03068046	A2	8/2003
WO	03090630	A2	11/2003
WO	03096880	A2	11/2003
WO	03101311	A1	12/2003
WO	2004028585	A2	4/2004
WO	2004032776	A1	4/2004
WO	2004032777	A1	4/2004
WO	2004052221	A1	6/2004
WO	2004073488	A2	9/2004
WO	2004073490	A2	9/2004
WO	2004073753	A2	9/2004
WO	2004082495	A1	9/2004
WO	2004083797	A2	9/2004
WO	2004098383	A2	11/2004
WO	2004103156	A2	12/2004
WO	2005004734	A1	1/2005
WO	2005004735	A1	1/2005
WO	2005009255	A1	2/2005
WO	2006021269	A1	3/2006
WO	2005110264	A2	4/2006
WO	2008008457	A2	1/2008
WO	2008040483	A1	4/2008
WO	2008045348	A2	4/2008
WO	2008045350	A2	4/2008
WO	20080112147	A1	9/2008
WO	20090005850	A1	1/2009
WO	2009039179	A1	3/2009
WO	2009039510	A1	3/2009
WO	2009124097	A1	10/2009
WO	2010104753	A1	9/2010
WO	2011018154	A1	2/2011

OTHER PUBLICATIONS

International Search Report PCT/US01/11224 dated Nov. 13, 2001.
International Search Report EP 98958575.7 dated Sep. 20, 2002.
International Search Report EP 04013772 dated Apr. 1, 2005.
International Search Report EP 05013895 dated Oct. 14, 2005.
International Search Report EP 05017281 dated Nov. 16, 2005.
Int'l Search Report EP 05016399 dated Jan. 5, 2006.
Int'l Search Report EP 06005185.1 dated Apr. 18, 2006.
Int'l Search Report EP 06008779.8 dated Jun. 13, 2006.
Int'l Search Report EP 1683496 dated Jun. 13, 2006.
Int'l Search Report EP 06014461.5 dated Oct. 20, 2006.
Int'l Search Report EP 06020584.6 dated Jan. 12, 2007.
Int'l Search Report EP 06020583.8 dated Jan. 30, 2007.
Int'l Search Report EP 06020756.0 dated Feb. 5, 2007.
Int'l Search Report EP 06024123.9 dated Feb. 26, 2007.
Int'l Search Report EP 06 024122.1 dated Mar. 19, 2007.
Int'l Search Report EP 07 001480.8 dated Apr. 12, 2007.
Int'l Search Report EP 07 001488.1 dated May 29, 2007.
Int'l Search Report Extended—EP 07 009029.5 dated Jul. 12, 2007.
Int'l Search Report EP 07 009321.6 dated Aug. 17, 2007.
Japanese Office Action (with English translation), dated Aug. 31, 2016, corresponding to Japanese Application No. 2011-102433; 11 total pages.
Canadian Office Action and Examination Report, dated Sep. 23, 2016, corresponding to Canadian Application No. 2.738,240; 6 total pages.
U.S. Appl. No. 12/399,614, filed Mar. 6, 2009.
U.S. Appl. No. 12/195,624, filed Aug. 21, 2008.
U.S. Appl. No. 12/367,791, filed Feb. 9, 2009.
U.S. Appl. No. 12/361,367, filed Jan. 28, 2009.
U.S. Appl. No. 12/361,375, filed Jan. 28, 2009.
U.S. Appl. No. 12/400,901, filed Mar. 10, 2009.
U.S. Appl. No. 12/176,679, filed Jul. 21, 2008.
U.S. Appl. No. 12/237,515, filed Sep. 25, 2008.
U.S. Appl. No. 12/204,976, filed Sep. 5, 2008.
U.S. Appl. No. 12/192,170, filed Aug. 15, 2008.
U.S. Appl. No. 12/233,157, filed Sep. 18, 2008.
U.S. Appl. No. 12/237,582, filed Sep. 25, 2008.
U.S. Appl. No. 12/210,598, filed Sep. 15, 2008.
U.S. Appl. No. 12/200,154, filed Aug. 28, 2008.
U.S. Appl. No. 12/211,205, filed Sep. 16, 2008.
U.S. Appl. No. 12/244,873, filed Oct. 3, 2008.
U.S. Appl. No. 12/246,553, filed Oct. 7, 2008.
U.S. Appl. No. 12/248,115, filed Oct. 9, 2008.
U.S. Appl. No. 12/353,474, filed Jan. 14, 2009.
U.S. Appl. No. 12/353,470, filed Jan. 14, 2009.
U.S. Appl. No. 12/352,942, filed Jan. 13, 2009.
U.S. Appl. No. 12/237,556, filed Sep. 25, 2008.
U.S. Appl. No. 12/411,542, filed Mar. 26, 2009.
U.S. Appl. No. 12/248,104, filed Oct. 9, 2008.
U.S. Appl. No. 12/254,123, filed Oct. 20, 2008.
U.S. Appl. No. 12/200,246, filed Aug. 28, 2008.
U.S. Appl. No. 12/200,396, filed Aug. 28, 2008.
U.S. Appl. No. 12/200,526, filed Aug. 28, 2008.
McLellan et al. "Vessel Sealing for Hemostasis During Gynecologic Surgery" Sales/Product Literature 1999.
Int'l Search Report EP 98944778.4 dated Oct. 31, 2000.
Int'l Search Report EP 98957771 dated Aug. 9, 2001.
Int'l Search Report EP 98958575.7 dated Sep. 20, 2002.
Int'l Search Report EP 04027314.6 dated Mar. 10, 2005.
Int'l Search Report EP 04027479.7 dated Mar. 8, 2005.
Int'l Search Report EP 04027705.5 dated Feb. 3, 2005.
Int'l Search Report EP 04752343.6 dated Jul. 20, 2007.
Int'l Search Report EP 05002671.5 dated Dec. 22, 2008.
Int'l Search Report PCT/US99/24869 dated Feb. 3, 2000.
Int'l Search Report PCT/US01/11218 dated Aug. 14, 2001.
Int'l Search Report PCT/US01/11340 dated Aug. 16, 2001.

(56) **References Cited**

OTHER PUBLICATIONS

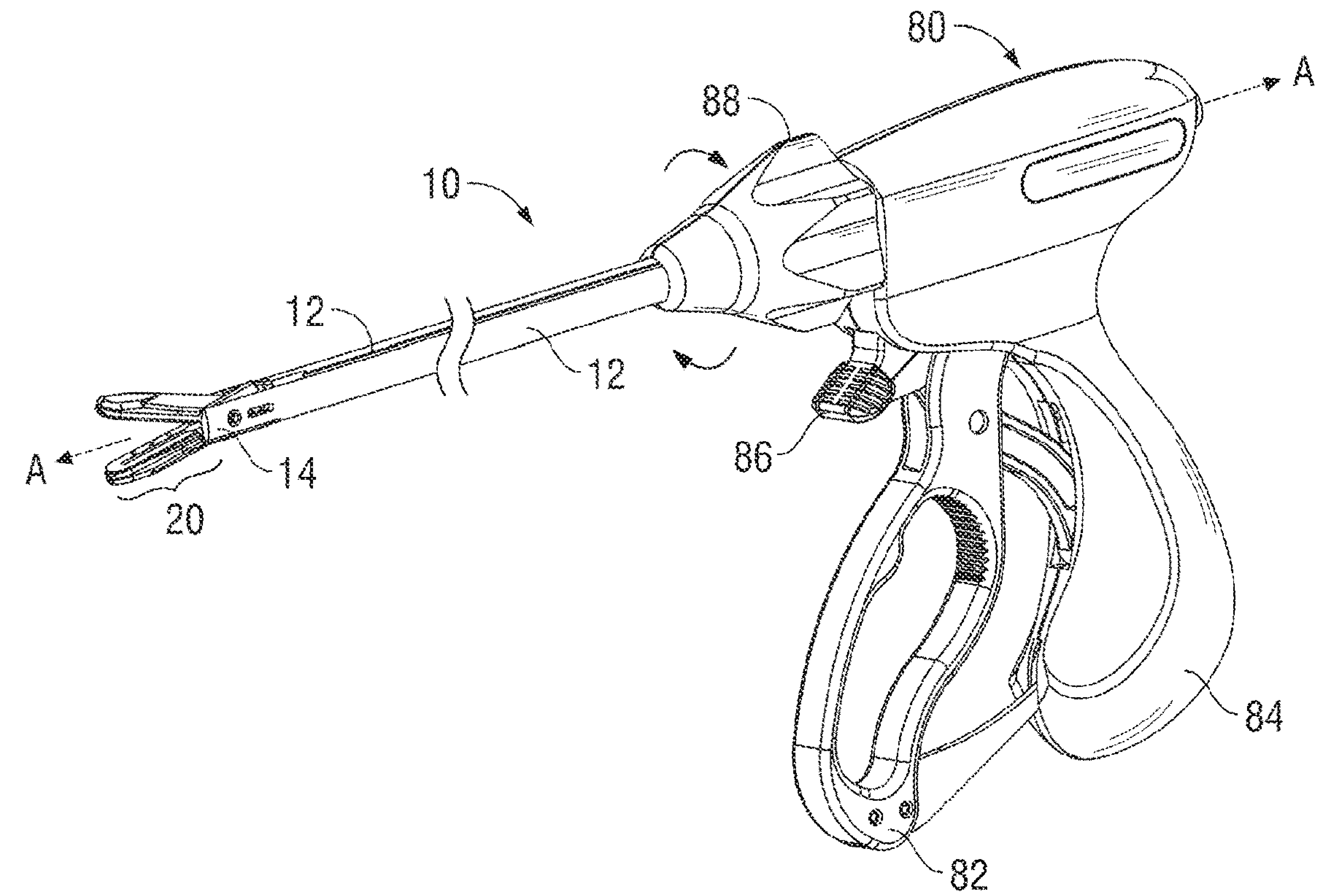
Int'l Search Report PCT/US01/11420 dated Oct. 16, 2001.
Int'l Search Report PCT/US02/01890 dated Jul. 25, 2002.
Int'l Search Report PCT/US02/11100 dated Jul. 16, 2002.
Int'l Search Report PCT/US03/28534dated Dec. 19, 2003.
Int'l Search Report PCT/US04/03436 dated Mar. 3, 2005.
Int'l Search Report PCT/US04/13273 dated Dec. 15, 2004.
Int'l Search Report PCT/US04/15311dated Jan. 12, 2005.
Int'l Search Report PCT/US07/021438 dated Apr. 1, 2008.
Int'l Search Report PCT/US07/021440 dated Apr. 8, 2008.
Int'l Search Report PCT/US08/61498 dated Sep. 22, 2008.
Int'l Search Report PCT/US09/032690 dated Jun. 16, 2009.
International Search Report EP06008515.6 dated Jan. 8, 2009.
Official Action issued by the Canadian Patent Office in co-pending Canadian Patent Application No. 2,442,598 dated Nov. 3, 2009.
European Search Report dated Aug. 31, 2011 for EP Appln. No. EP 10 16 7655.
US 6,090,109, 07/2000, Lands et al. (withdrawn)
US 6,663,629, 12/2003, Buysse et al. (withdrawn)
Crawford et al. "Use of the LigaSure Vessel Sealing System in Urologic Cancer Surger"; Grand Rounds in Urology 1999 vol. 1 Issue 4 pp. 10-17.
Int'l Search Report PCT/US01/11218.
Int'l Search Report PCT/US99/24869.
Int'l Search Report PCT/US98/18640.
Int'l Search Report PCT/US98/23950.
"Innovations in Electrosurgery" Sales/Product Literature.
Carbonell et al., "Comparison of theGyrus PlasmaKinetic Sealer and the Valleylab LigaSure Device in the Hemostasis of Small, Medium, and Large-Sized Arteries" Carolinas Laparoscopic and Advanced Surgery Program, Carolinas Medical Center, Charlotte,NC.
PCT/US01/11340, International Search Report.
PCT/US01/11420, International Search Report.
PCT/US02/01890, International Search Report.
PCT/US02/11100, International Search Report.
PCT/US04/03436, International Search Report.
PCT/US04/13273, International Search Report.
PCT/US04/15311, International Search Report.
EP 98944778, International Search Report.
EP 98958575, International Search Report.
EP 04027479, International Search Report.
EP 04027705, International Search Report.
EP 04027314, International Search Report.
Int'l Search Report EP 05013463.4 dated Sep. 28, 2005.
Int'l Search Report EP 05019130.3 dated Oct. 18, 2005.
Int'l Search Report EP 05020665.5 dated Feb. 16, 2006.
Int'l Search Report EP 05020666.3 dated Feb. 17, 2006.
Int'l Search Report EP 05021779.3 dated Jan. 18, 2006.
Int'l Search Report EP 05021197.8 dated Jan. 31, 2006.
Int'l Search Report EP 05021937.7 dated Jan. 13, 2006.
Int'l Search Report—extended—EP 05021937.7 dated Mar. 6, 2006.
Int'l Search Report EP 05023017.6 dated Feb. 16, 2006.
Int'l Search Report EP 05021780.1 dated Feb. 9, 2006.
Int'l Search Report EP 06002279.5 dated Mar. 22, 2006.
"Innovations in Electrosurgery" Sales/Product Literature; Dec. 31, 2000.
U.S. Appl. No. 12/236,666, filed Sep. 24, 2008.
U.S. Appl. No. 12/192,189, filed Aug. 15, 2008.
U.S. Appl. No. 12/192,243, filed Aug. 15, 2008.
U.S. Appl. No. 12/331,643, filed Dec. 10, 2008.
U.S. Appl. No. 12/353,466, filed Jan. 14, 2009.
U.S. Appl. No. 12/363,086, filed Jan. 30, 2009.
U.S. Appl. No. 12/419,729, filed Apr. 7, 2009.
"Reducing Needlestick Injuries in the Operating Room"; Sales/ Product Literature 2001.
U.S. Appl. No. 12/336,970, filed Dec. 17, 2008, Sremcich, Abandoned.
Int'l Search Report EP 05002674.9 dated Jan. 16, 2009.
Int'l Search Report EP 05013463.4 dated Oct. 7, 2005.
Int'l Search Report EP 05013895.7 dated Oct. 21, 2005.
Int'l Search Report EP 05016399.7 dated Jan. 13, 2006.
Int'l Search Report EP 05017281.6 dated Nov. 24, 2005.
Int'l Search Report EP 05019130.3 dated Oct. 27, 2005.
Int'l Search Report EP 05019429.9 dated May 6, 2008.
Int'l Search Report EP 05020665.5 dated Feb. 27, 2006.
Int'l Search Report EP 05020666.3 dated Feb. 27, 2006.
Int'l Search Report EP 05021197.8 dated Feb. 20, 2006.
Int'l Search Report EP 05021779.3 dated Feb. 2, 2006.
Int'l Search Report EP 05021780.1 dated Feb. 23, 2006.
Int'l Search Report EP 05021937.7 dated Jan. 23, 2006.
Int'l Search Report—extended—EP 05021937.7 dated Mar. 15, 2006.
Int'l Search Report EP 05023017.6 dated Feb. 24, 2006.
Int'l Search Report EP 06002279.5 dated Mar. 30, 2006.
Int'l Search Report EP 06005185.1 dated May 10, 2006.
Int'l Search Report EP 06006716.2 dated Aug. 4, 2006.
Int'l Search Report EP 06008515.6 dated Jan. 8, 2009.
Int'l Search Report EP 06008779.8 dated Jul. 13, 2006.
Int'l Search Report EP 06014461.5 dated Oct. 31, 2006.
Int'l Search Report EP 06020574.7 dated Oct. 2, 2007.
Int'l Search Report EP 06020583.8 dated Feb. 7, 2007.
Int'l Search Report EP 06020584.6 dated Feb. 1, 2007.
Int'l Search Report EP 06020756.0 dated Feb. 16, 2007.
Int'l Search Report EP 06 024122.1 dated Apr. 16, 2007.
Int'l Search Report EP 06024123.9 dated Mar. 6, 2007.
Int'l Search Report EP 07 001480.8 dated Apr. 19, 2007.
Int'l Search Report EP 07 001488.1 dated Jun. 5, 2007.
Int'l Search Report EP 07 009026.1 dated Oct. 8, 2007.
Int'l Search Report Extended—EP 07 009029.5 dated Jul. 20, 2007.
Int'l Search Report EP 07 009321.6 dated Aug. 28, 2007.
Int'l Search Report EP 07 010672.9 dated Oct. 16, 2007.
Int'l Search Report EP 07 013779.9 dated Oct. 26, 2007.
Int'l Search Report EP 07 014016 dated Jan. 28, 2008.
Int'l Search Report EP 07 015191.5 dated Jan. 23, 2008.
Int'l Search Report EP 07 015601.3 dated Jan. 4, 2008.
Int'l Search Report EP 07 020283.3 dated Feb. 5, 2008.
Int'l Search Report EP 07 021646.0 dated Jul. 9, 2008.
Int'l Search Report EP 07 021647.8 dated May 2, 2008.
Int'l Search Report EP 08 002692.5 dated Dec. 12, 2008.
Int'l Search Report EP 08 004655.0 dated Jun. 24, 2008.
Int'l Search Report EP 08 006732.5 dated Jul. 29, 2008.
Int'l Search Report EP 08 006917.2 dated Jul. 3, 2008.
Int'l Search Report EP 08 016539.2 dated Jan. 8, 2009.
Int'l Search Report EP 09 152267.2 dated Jun. 15, 2009.
Int'l Search Report EP 09 152898.4 dated Jun. 10, 2009.
Int'l Search Report PCT/US98/18640 dated Jan. 29, 1999.
Int'l Search Report PCT/US98/23950 dated Jan. 14, 1999.
Int'l Search Report PCT/US98/24281 dated Feb. 22, 1999.
U.S. Appl. No. 12/336,970, filed Dec. 17, 2008.
Michael Choti, "Abdominoperineal Resection with the LigaSure Vessel Sealing System and LigaSure Atlas 20 cm Open Instrument" Innovations That Work, Jun. 2003.
Chung et al., "Clinical Experience of Sutureless Closed Hemorrhoidectomy with LigaSure" Diseases of the Colon & Rectum vol. 46, No. 1 Jan. 2003.
Carbonell et al., "Comparison of theGyrus PlasmaKinetic Sealer and the Valleylab LigaSure Device in the Hemostasis of Small, Medium, and Large-Sized Arteries" Carolinas Laparoscopic and Advanced Surgery Program, Carolinas Medical Center,Charlotte,NC; Date: Aug. 2003.
Peterson et al., "Comparison of Healing Process Following Ligation with Sutures and Bipolar Vessel Sealing" Surgical Technology International (2001).
"Electrosurgery: A Historical Overview" Innovations in Electrosurgery; Sales/Product Literature; Dec. 31, 2000, 6 pages.
Johnson et al. "Evaluation of a Bipolar Electrothermal Vessel Sealing Device in Hemorrhoidectomy" Sales/Product Literature; Jan. 2004.
E. David Crawford, "Evaluation of a New Vessel Sealing Device in Urologic Cancer Surgery" Sales/Product Literature 2000.

(56) **References Cited**

OTHER PUBLICATIONS

Johnson et al. "Evaluation of the LigaSure Vessel Sealing System in Hemorrhoidectormy" American College of Surgeons (ACS) Clinicla Congress Poster (2000).
Muller et al. "Extended Left Hemicolectomy Using the LigaSure Vessel Sealing System" Innovations That Work; Sep. 1999.
Kennedy et al. "High-burst-strength, feedback-controlled bipolar vessel sealing" Surgical Endoscopy (1998) 12:876-878.
Carus et al., "Initial Experience With the LigaSure Vessel Sealing System in Abdominal Surgery" Innovations That Work,Jun. 2002.
Heniford et al. "Initial Research and Clinical Results with an Electrothermal Bipolar Vessel Sealer" Oct. 1999.
Heniford et al. "Initial Results with an Electrothermal Bipolar Vessel Sealer" Surgical Endoscopy (2000) 15:799-801. (4 pages).
Herman et al., "Laparoscopic Intestinal Resection With the LigaSure Vessel Sealing System: A Case Report"; Innovations That Work, Feb. 2002.
Koyle et al., "Laparoscopic Palomo Varicocele Ligation in Children and Adolescents" Pediatric Endosurgery & Innovative Techniques, vol. 6, No. 1, 2002.
W. Scott Helton, "LigaSure Vessel Sealing System: Revolutionary Hemostasis Product for General Surgery"; Sales/Product Literature 1999.
LigaSure Vessel Sealing System, the Seal of Confidence in General, Gynecologic, Urologic, and Laparaoscopic Surgery; Sales/Product Literature; Apr. 2002.
Joseph Ortenberg "LigaSure System Used in Laparoscopic 1st and 2nd Stage Orchiopexy" Innovations That Work, Nov. 2002.
Sigel et al., "The Mechanism of Blood Vessel Closure by High Frequency Electrocoagulation" Surgery Gynecology & Obstetrics, Oct. 1965 pp. 823-831.
Sampayan et al, "Multilayer Ultra-High Gradient Insulator Technology" Discharges and Electrical Insulation in Vacuum, 1998. Netherlands Aug. 17-21, 1998; vol. 2, pp. 740-743.
Paul G. Horgan, "A Novel Technique for Parenchymal Division During Hepatectomy" The American Journal of Surgery, vol. 181, No. 3, Apr. 2001 pp. 236-237.
Olsson et al. "Radical Cystectomy in Females". Current Surgical Techniques in Urology, vol. 14, Issue 3, 2001.
Palazzo et al. "Randomized clinical trial of Ligasure versus open haemorrhoidectomy" British Journal of Surgery 2002, 89, 154-157.
Levy et al. "Randomized Trial of Suture Versus Electrosurgical Bipolar Vessel Sealing in Vaginal Hysterectomy" Obstetrics & Gynecology, vol. 102, No. 1, Jul. 2003.
"Reducing Needlestick Injuries in the Operating Room" Sales/Product Literature 2001. (1 page).
Bergdahl et al., "Studies on Coagulation and the Development of an Automatic Computerized Bipolar Coagulator" J. Neurosurg, vol. 75, Jul. 1991, pp. 148-151.
Strasberg et al. "A Phase I Study of the LigaSure Vessel Sealing System in Hepatic Surgery" Section of HPB Surger, Washington University School of Medicine, St. Louis MO, Presented at AHPBA , Feb. 2001.
Sayfan et al., "Sutureless Closed Hemorrhoidectomy: A New Technique" Annals of Surgery, vol. 234, No. 1, Jul. 2001, pp. 21-24.
Levy et al., "Update on Hysterectomy—New Technologies and Techniques" OBG Management, Feb. 2003.
Dulemba et al. "Use of a Bipolar Electrothermal Vessel Sealer in Laparoscopically Assisted Vaginal Hysterectomy" Sales/Product Literature; Jan. 2004.
Strasberg et al., "Use of a Bipolar Vessel-Sealing Device for Parenchymal Transection During Liver Surgery" Journal of Gastrointestinal Surgery, vol. 6, No. 4, Jul./Aug. 2002 pp. 569-574.
Sengupta et al., "Use of a Computer-Controlled Bipolar Diathermy System in Radical Prostatectomies and Other Open Urological Surgery" ANZ Journal of Surgery (2001)71.9 pp. 538-540.
Rothenberg et al. "Use of the LigaSure Vessel Sealing System in Minimally Invasive Surgery in Children" Int'l Pediatric Endosurgery Group (IPEG) 2000.
Craig Johnson, "Use of the LigaSure Vessel Sealing System in Bloodless Hemorrhoidectomy"; Innovations That Work, Mar. 2000.
Levy et al. "Use of a New Energy-based Vessel Ligation Device During Vaginal Hysterectomy"; Int'l Federation of Gynecology and Obstetrics (FIGO) World Congress 1999.
Barbara Levy, "Use of a New Vessel Ligation Device During Vaginal Hysterectomy" FIGO 2000, Washington, D.C.. (1 page).
E. David Crawford, "Use of a Novel Vessel Sealing Technology in Management of the Dorsal Veinous Complex" Sales/Product Literature 2000.
Jarrett et al., "Use of the LigaSure Vessel Sealing System for Peri-Hilar Vessels in Laparoscopic Nephrectomy"; Sales/Product Literature 2000.
Crouch et al. "A Velocity-Dependent Model for Needle Insertion in Soft Tissue"; MICCAI 2005; LNCS 3750 pp. 624-632, Dated: 2005.
McLellan et al., "Vessel Sealing for Hemostasis During Pelvic Surgery" Int'l Federation of Gynecology and Obstetrics FIGO World Congress 2000, Washington, DC.

* cited by examiner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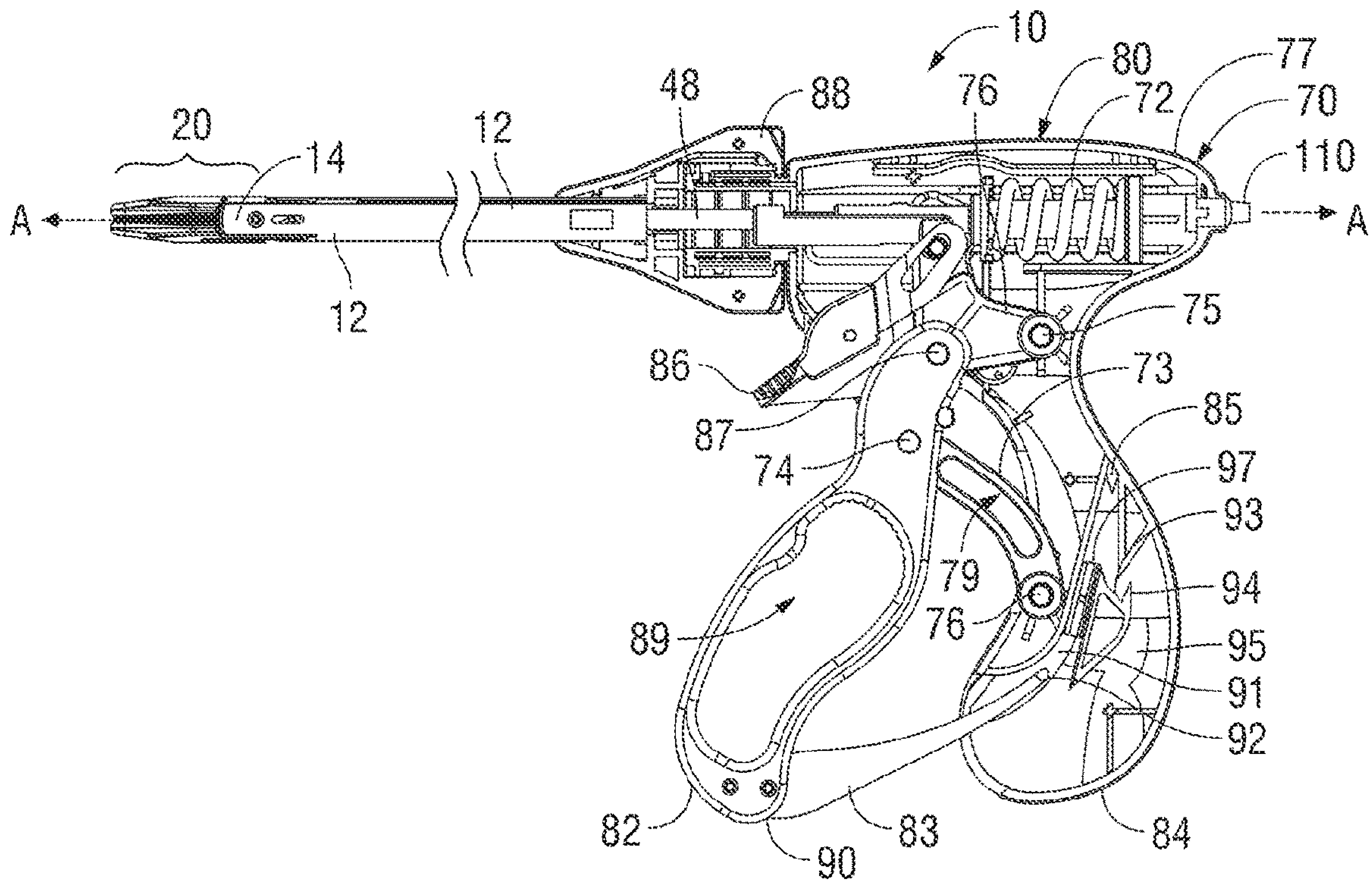
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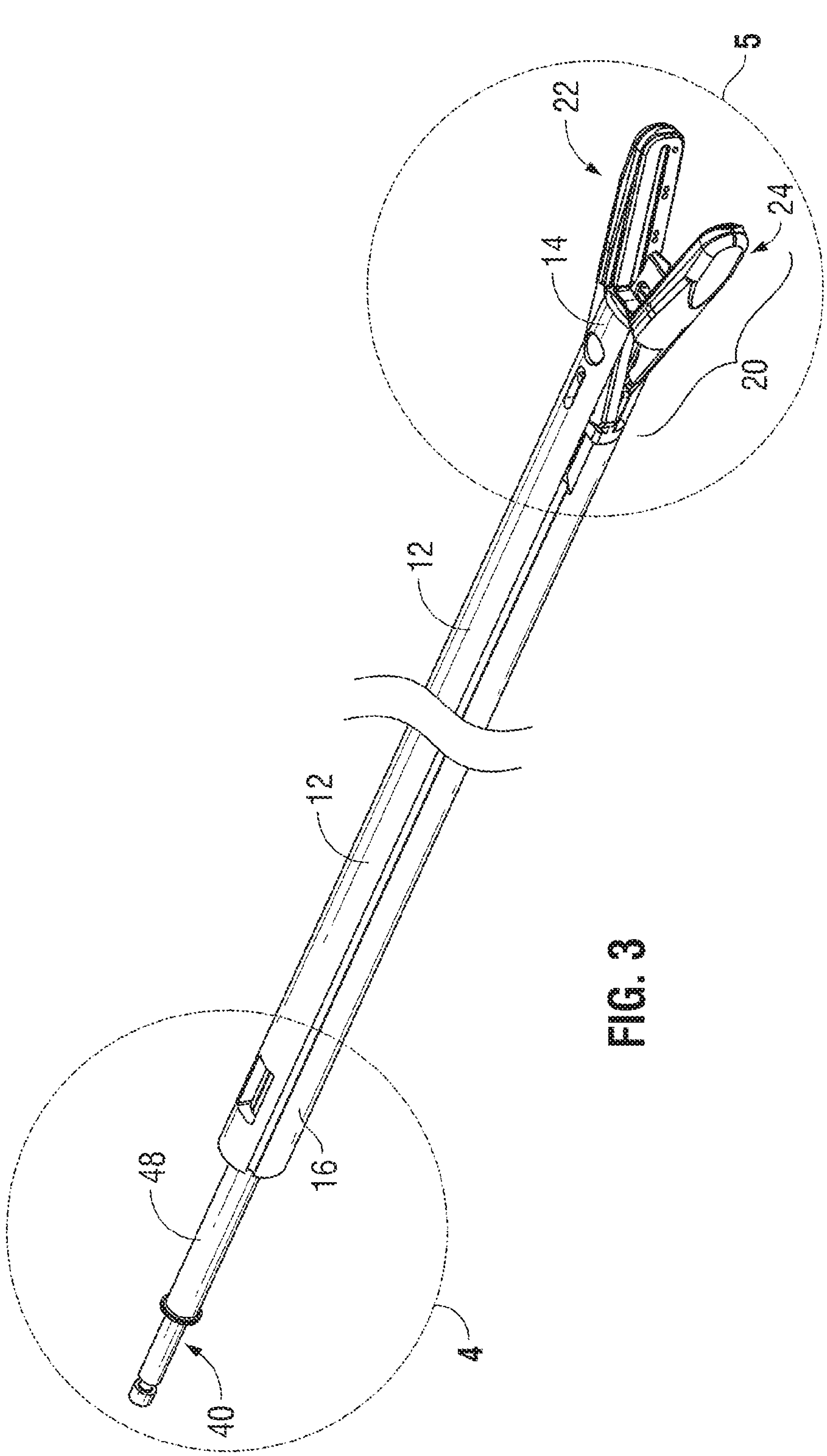
FIG. 2



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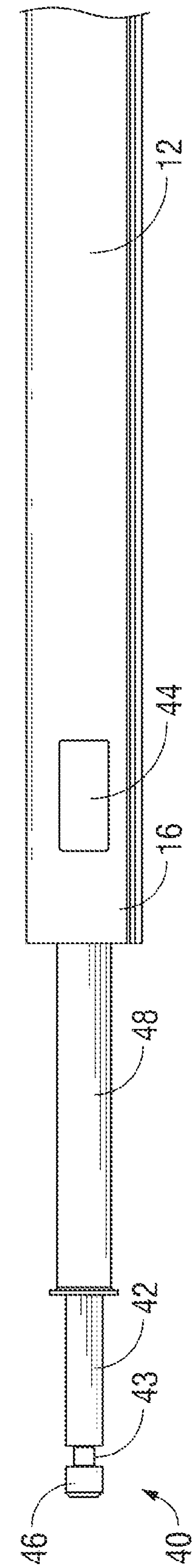

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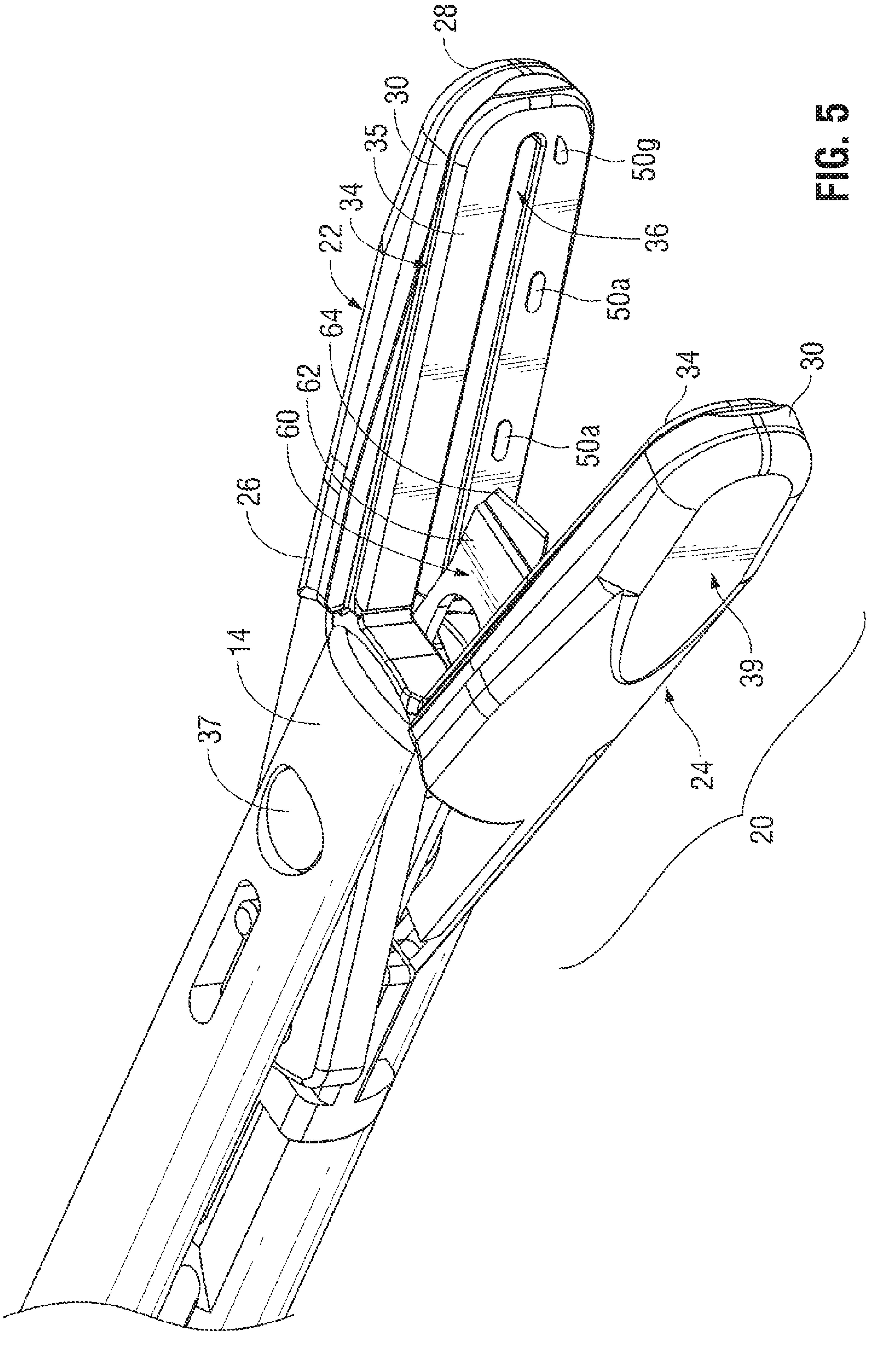

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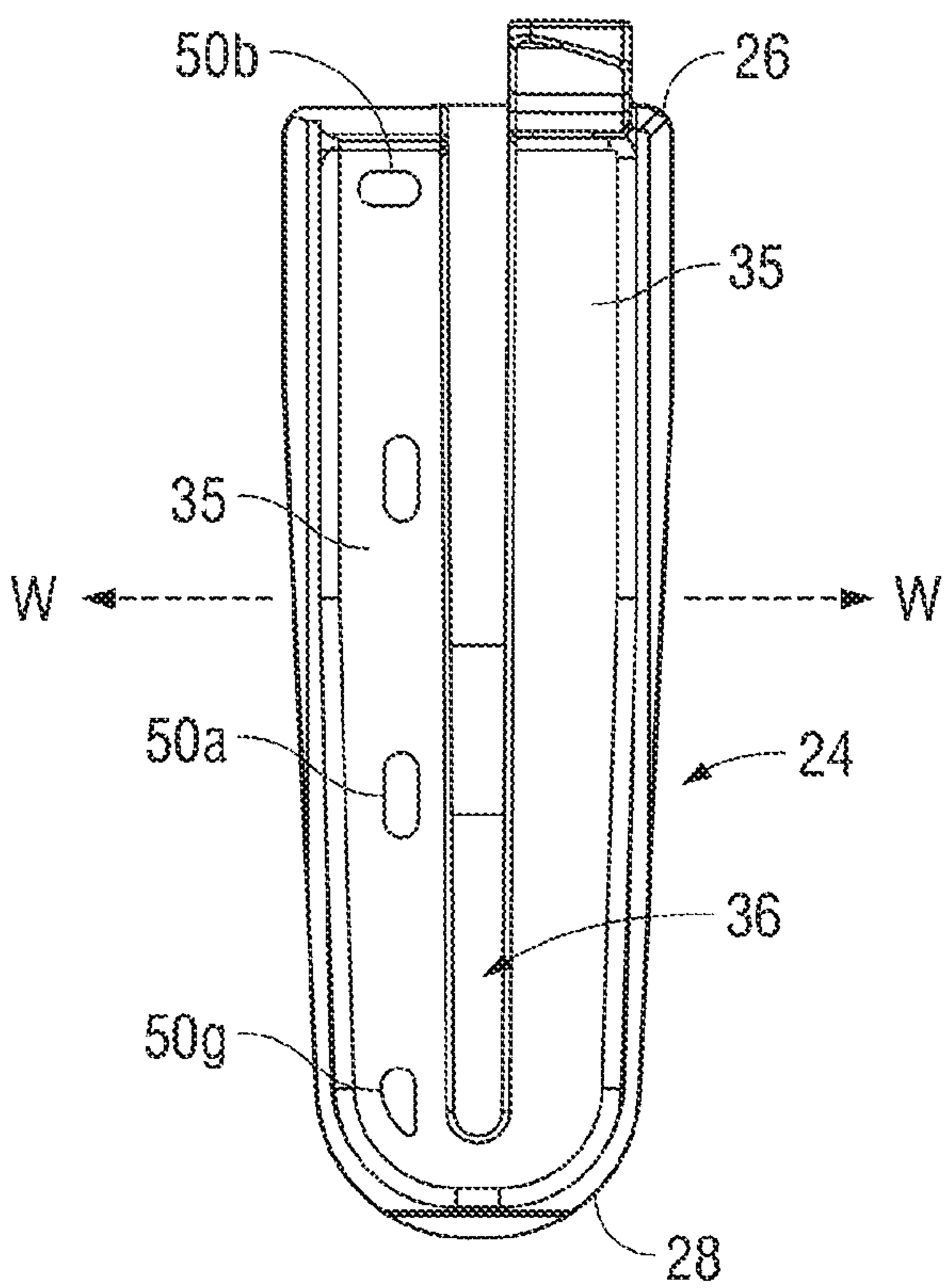


FIG. 6A

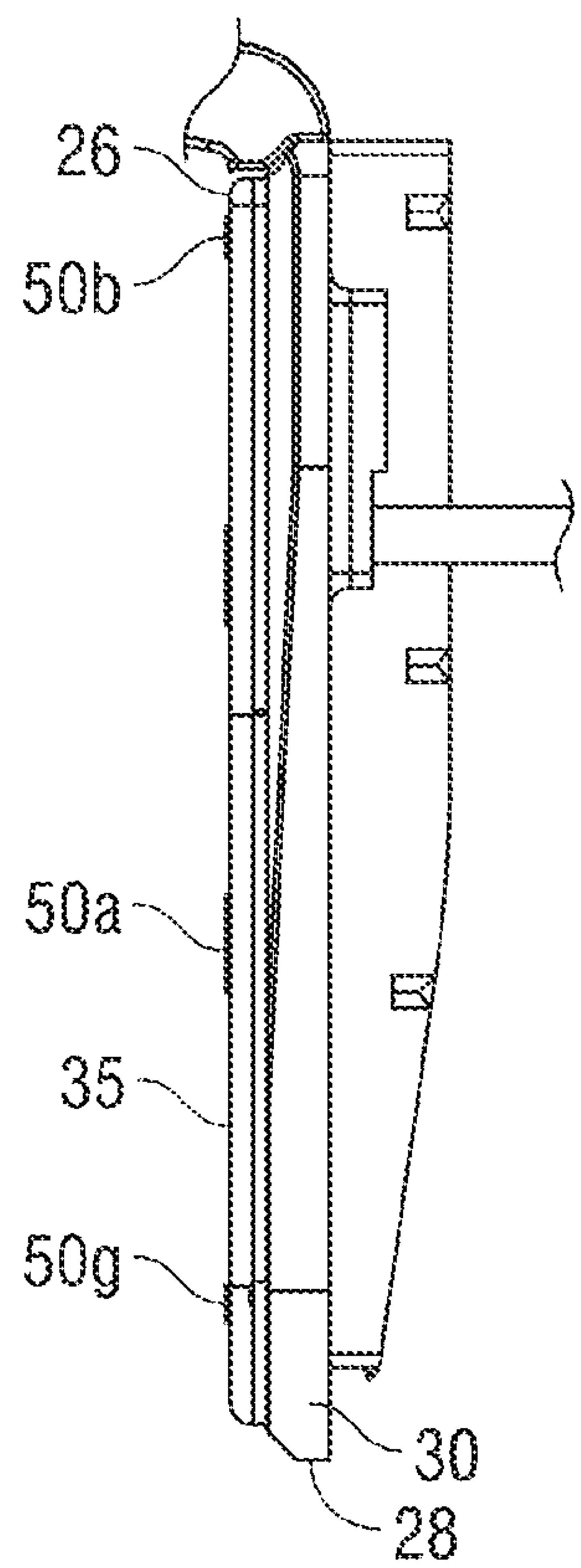


FIG. 6B

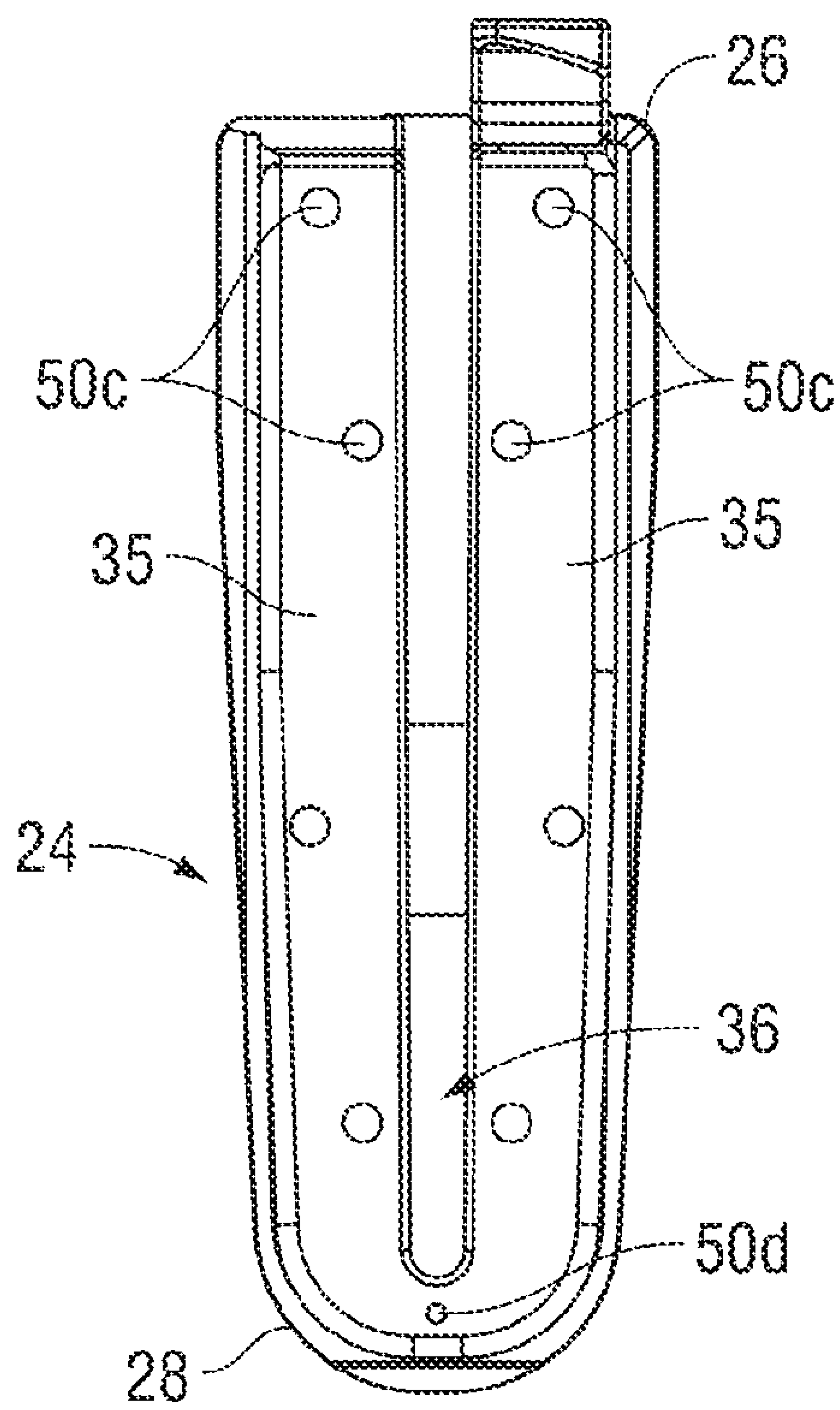


FIG. 6C

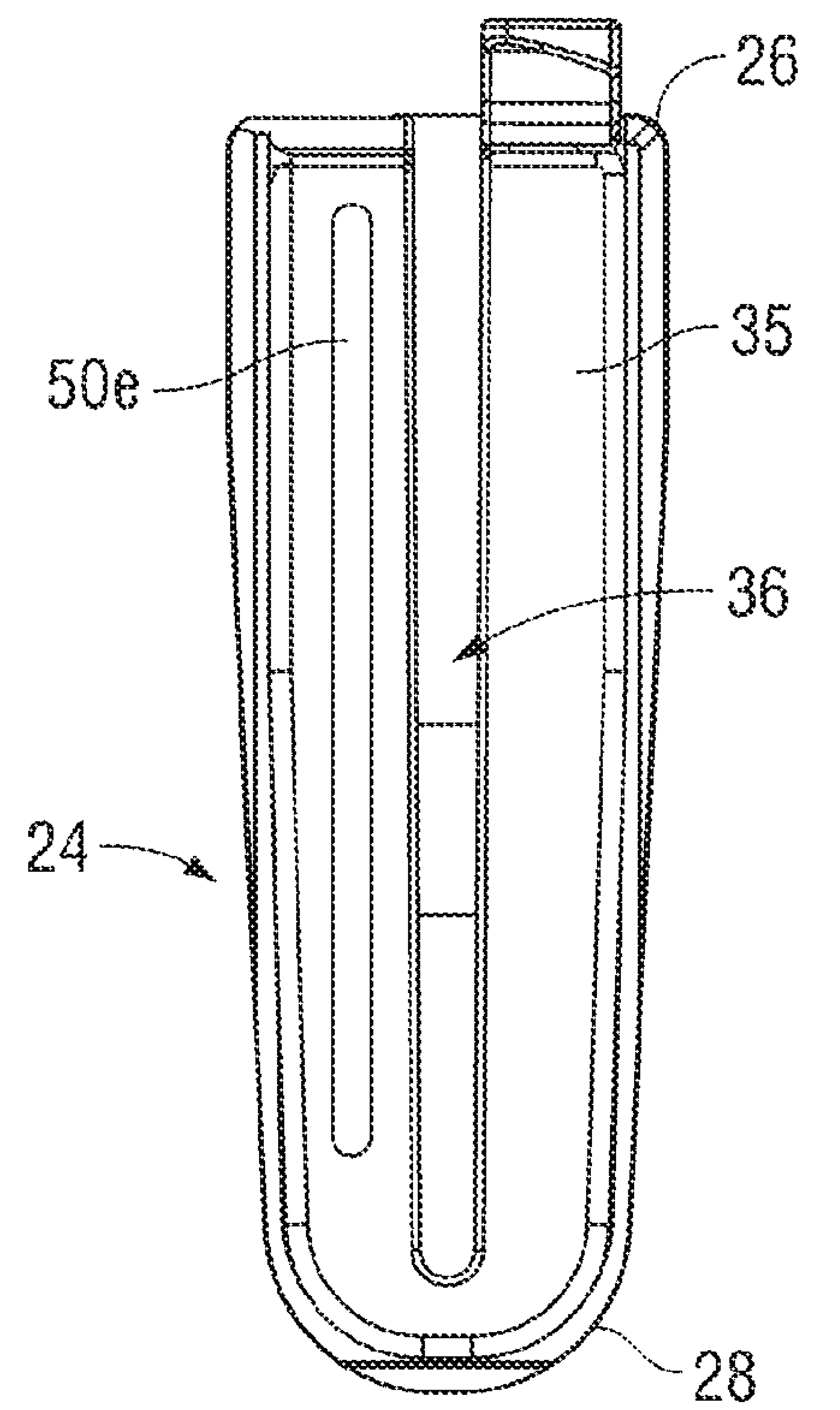


FIG. 6D

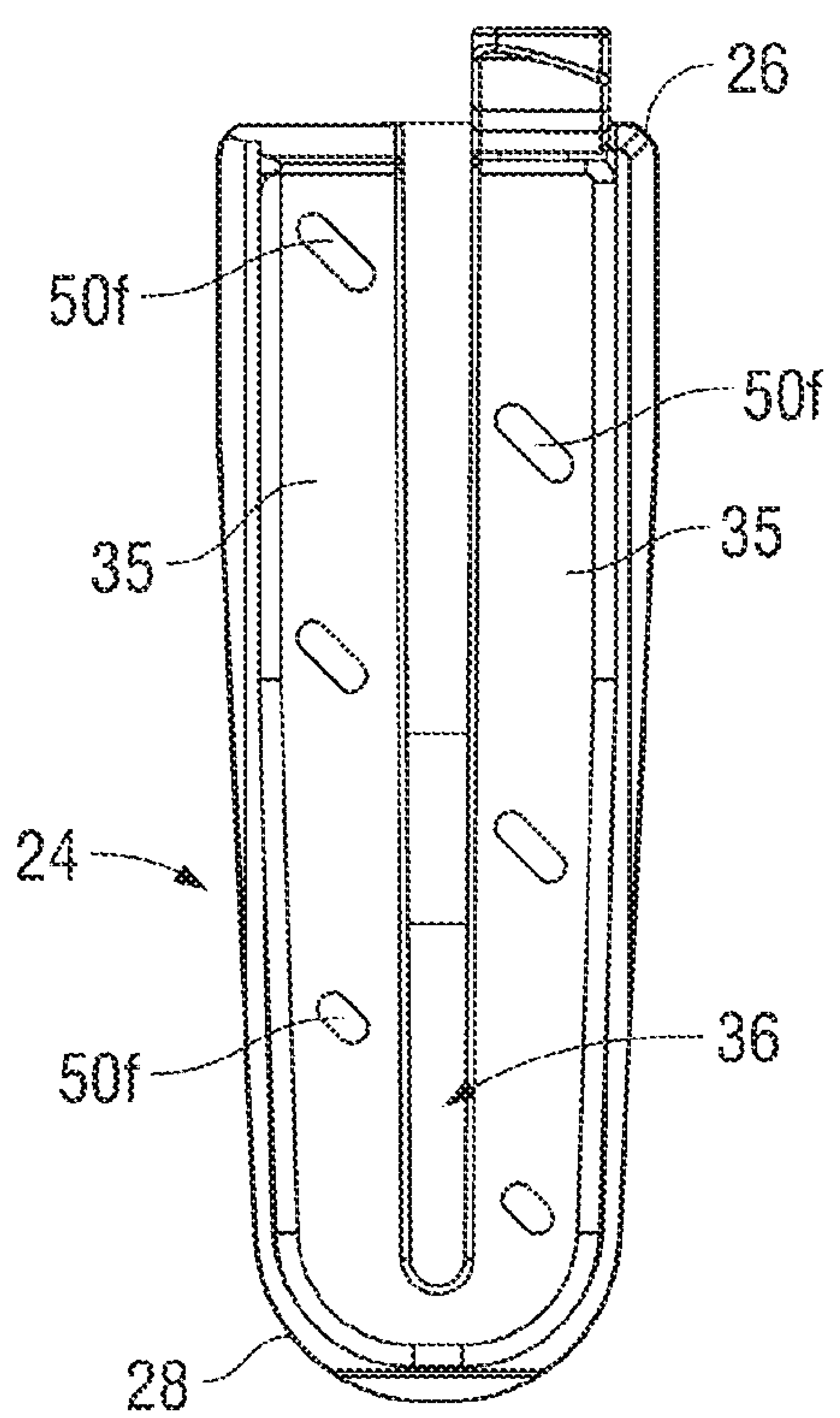
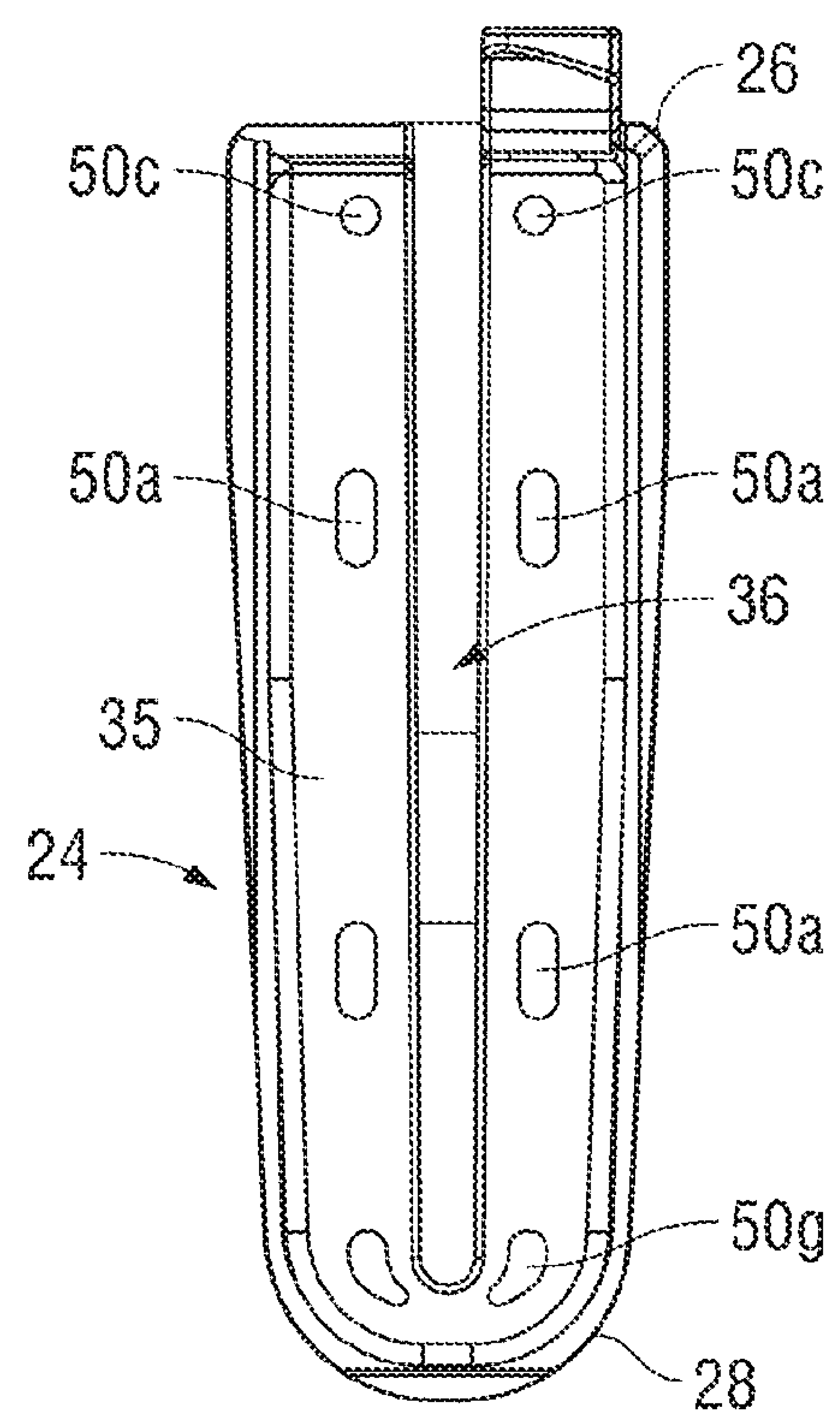


FIG. 6E



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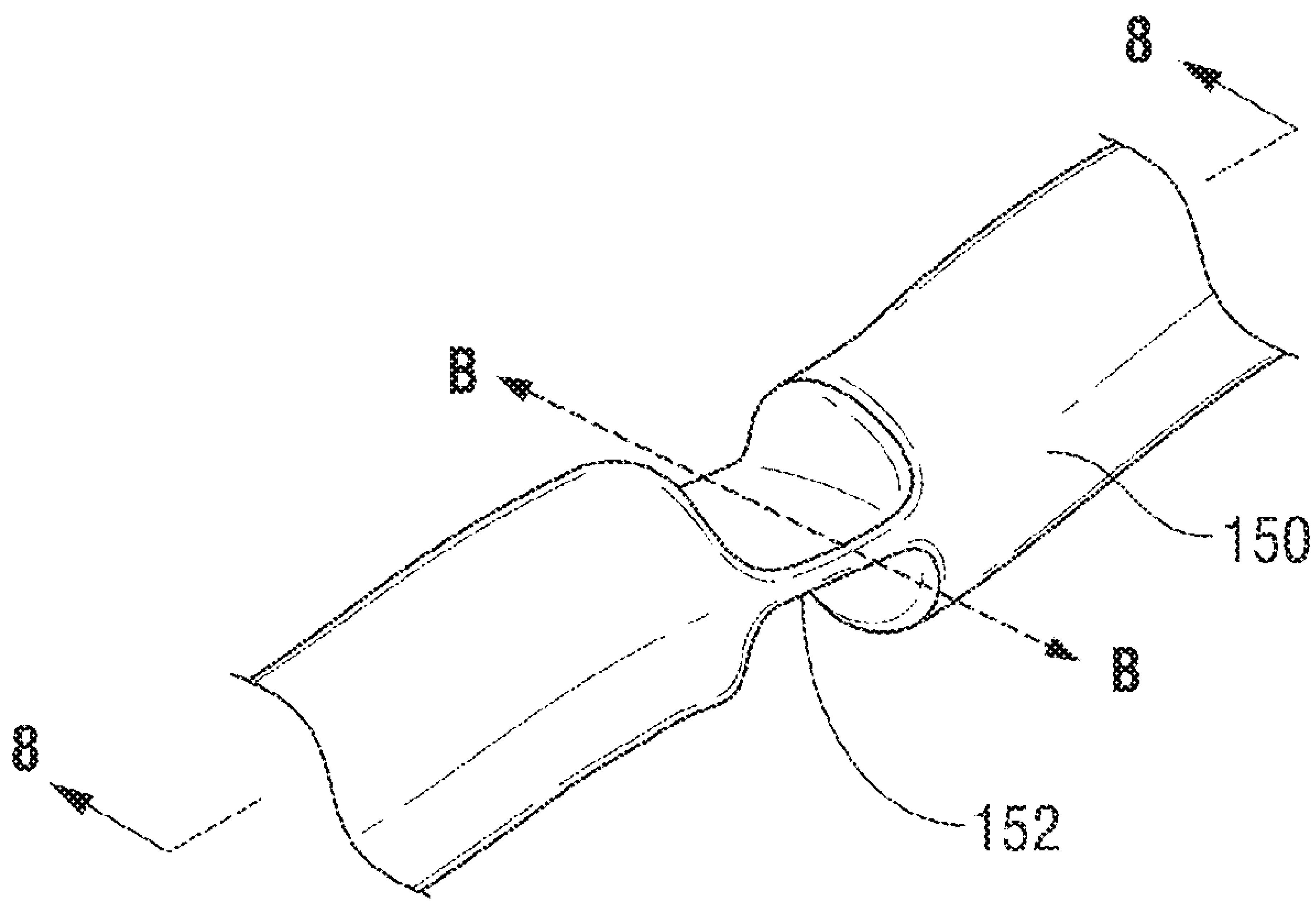

FIG. 7

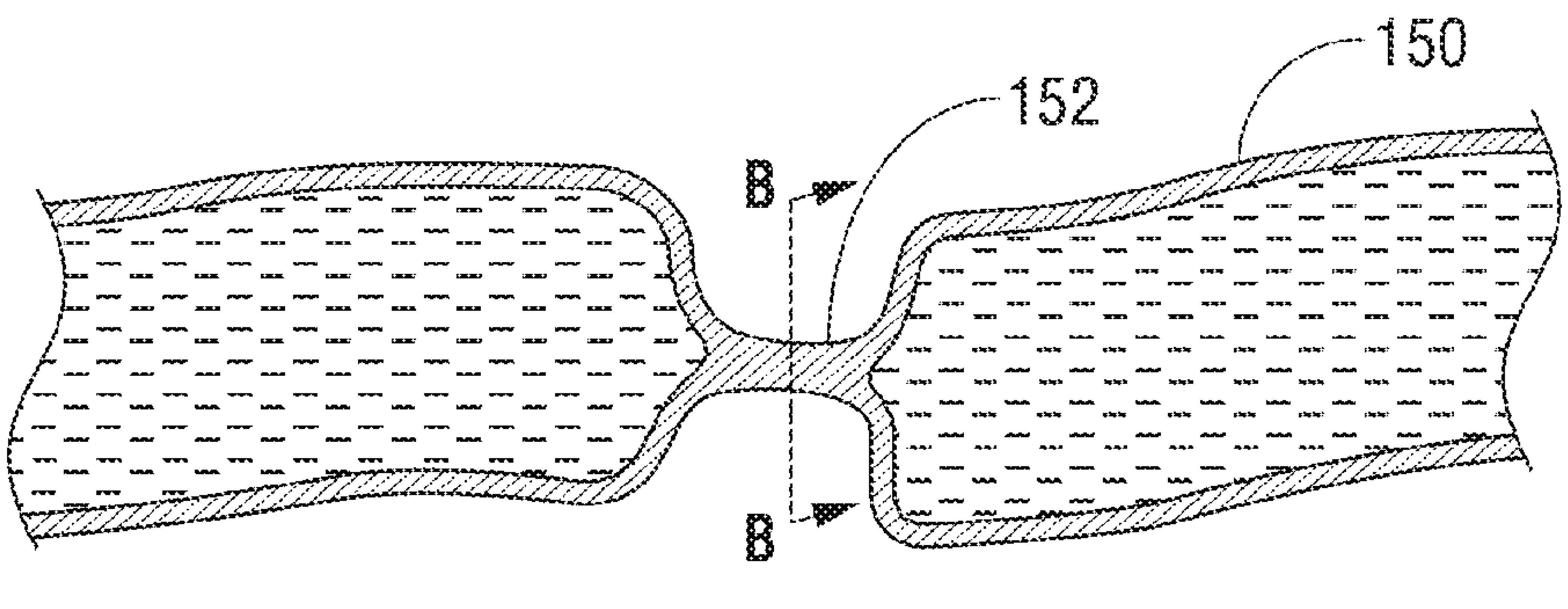

FIG. 8

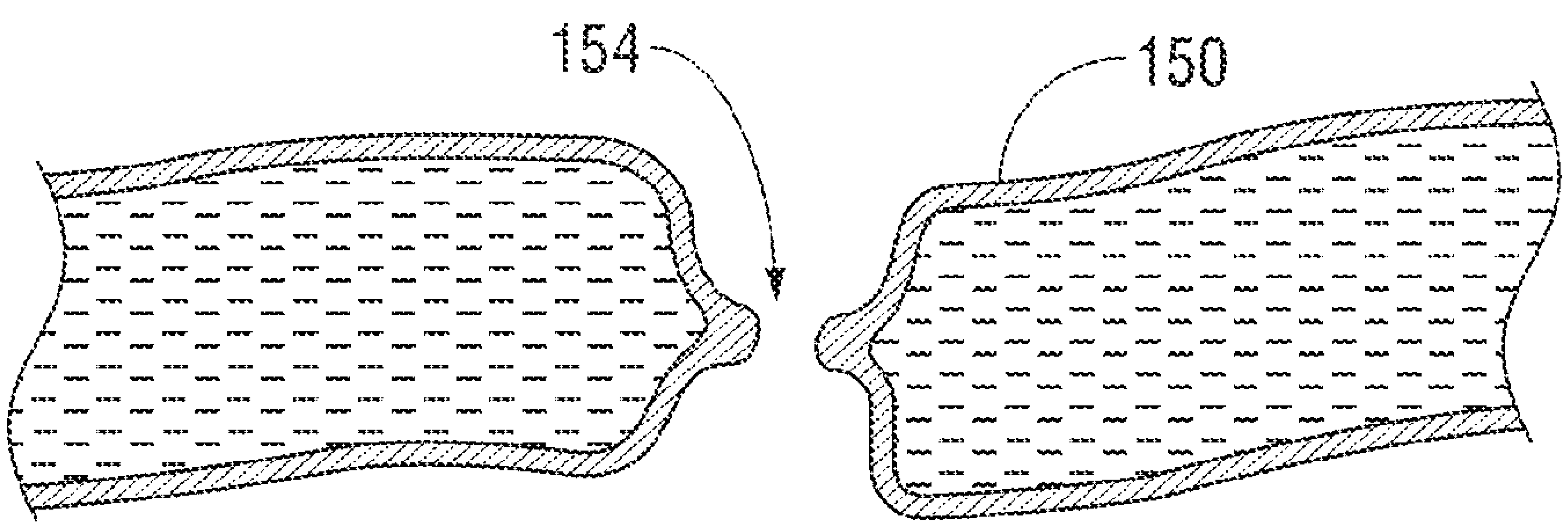

FIG. 9

VESSEL SEALER AND DIVIDER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 16/053,052, filed on Aug. 2, 2018, now U.S. Pat. No. 10,265,121, which is a continuation of U.S. application Ser. No. 15/911,739, filed on Mar. 5, 2018, now U.S. Pat. No. 10,251,696, which is a continuation of U.S. application Ser. No. 15/338,663, filed on Oct. 31, 2016, which is a continuation of U.S. application Ser. No. 14/719,887, filed on May 22, 2015, which is a continuation of U.S. application Ser. No. 13/584,194, filed on Aug. 13, 2012, which is a continuation of U.S. application Ser. No. 12/348,748, filed on Jan. 5, 2009, now U.S. Pat. No. 8,241,284, which is a continuation of U.S. application Ser. No. 10/471,818, filed on Sep. 11, 2003, now U.S. Pat. No. 7,473,253, which claims the benefit of and priority to PCT Application Serial No. PCT/US01/11413, filed Apr. 6, 2001, entitled "VESSEL SEALER AND DIVIDER WITH NON-CONDUCTIVE STOP MEMBERS", the entire contents of each of these applications is hereby incorporated by reference.

BACKGROUND

The present disclosure relates to an electrosurgical instrument and method for performing endoscopic surgical procedures. More particularly, the present disclosure relates to an endoscopic bipolar electrosurgical forceps and method of using same which includes a non-conductive stop member associated with one or both of the opposing jaw members. The non-conductive stop member is designed to control the gap distance between opposing jaw members and enhance the manipulation and gripping of tissue during the sealing and dividing process.

TECHNICAL FIELD

Endoscopic forceps utilize mechanical action to constrict, grasp, dissect and/or clamp tissue. Endoscopic electrosurgical forceps utilize both mechanical clamping action and electrical energy to effect hemostasis by heating the tissue and blood vessels to coagulate, cauterize and/or seal tissue.

Endoscopic instruments are inserted into the patient through a cannula, or port, that has been made with a trocar or similar such device. Typical sizes for cannulas range from three millimeters to twelve millimeters. Smaller cannulas are usually preferred, and this presents a design challenge to instrument manufacturers who must find ways to make surgical instruments that fit through the cannulas.

Certain endoscopic surgical procedures require cutting blood vessels or vascular tissue. However, due to space limitations surgeons can have difficulty suturing vessels or performing other traditional methods of controlling bleeding, e.g., clamping and/or tying-off transected blood vessels. Blood vessels, in the range below two millimeters in diameter, can often be closed using standard electrosurgical techniques. However, if a larger vessel is severed, it may be necessary for the surgeon to convert the endoscopic procedure into an open-surgical procedure and thereby abandon the benefits of laparoscopy.

Several journal articles have disclosed methods for sealing small blood vessels using electrosurgery. An article entitled Studies on Coagulation and the Development of an Automatic Computerized Bipolar Coagulator, J. Neurosurg., Volume 75, July 1991, describes a bipolar coagulator which

is used to seal small blood vessels. The article states that it is not possible to safely coagulate arteries with a diameter larger than 2 to 2.5 mm A second article is entitled Automatically Controlled Bipolar Electrocoagulation—"COA-COMP", Neurosurg. Rev. (1984), pp. 187-190, describes a method for terminating electrosurgical power to the vessel so that charring of the vessel walls can be avoided.

As mentioned above, by utilizing an electrosurgical forceps, a surgeon can either cauterize, coagulate/desiccate and/or simply reduce or slow bleeding, by controlling the intensity, frequency and duration of the electrosurgical energy applied through the jaw members to the tissue. The electrode of each jaw member is charged to a different electric potential such that when the jaw members grasp tissue, electrical energy can be selectively transferred through the tissue.

In order to effect a proper seal with larger vessels, two predominant mechanical parameters must be accurately controlled—the pressure applied to the vessel and the gap distance between the electrodes—both of which are affected by the thickness of the sealed vessel. More particularly, accurate application of pressure is important to oppose the walls of the vessel; to reduce the tissue impedance to a low enough value that allows enough electrosurgical energy through the tissue; to overcome the forces of expansion during tissue heating; and to contribute to the end tissue thickness which is an indication of a good seal. It has been determined that a typical fused vessel wall is optimum between 0.001 and 0.005 inches. Below this range, the seal may shred or tear and above this range the lumens may not be properly or effectively sealed.

Electrosurgical methods may be able to seal larger vessels using an appropriate electrosurgical power curve, coupled with an instrument capable of applying a large closure force to the vessel walls. It is thought that the process of coagulating small vessels is fundamentally different than electrosurgical vessel sealing. For the purposes herein, "coagulation" is defined as a process of desiccating tissue wherein the tissue cells are ruptured and dried. Vessel sealing is defined as the process of liquefying the collagen in the tissue so that it reforms into a fused mass. Thus, coagulation of small vessels is sufficient to permanently close them. Larger vessels need to be sealed to assure permanent closure.

U.S. Pat. No. 2,176,479 to Willis, U.S. Pat. Nos. 4,005,714 and 4,031,898 to Hiltebrandt, U.S. Pat. Nos. 5,827,274, 5,290,287 and 5,312,433 to Boebel et al., U.S. Pat. Nos. 4,370,980, 4,552,143, 5,026,370 and 5,116,332 to Lottick, U.S. Pat. No. 5,443,463 to Stern et al., U.S. Pat. No. 5,484,436 to Eggers et al. and U.S. Pat. No. 5,951,549 to Richardson et al., all relate to electrosurgical instruments for coagulating, cutting and/or sealing vessels or tissue. However, some of these designs may not provide uniformly reproducible pressure to the blood vessel and may result in an ineffective or non-uniform seal.

For the most part, these instruments rely on clamping pressure alone to procure proper sealing thickness and are not designed to take into account gap tolerances and/or parallelism and flatness requirements which are parameters which, if properly controlled, can assure a consistent and effective tissue seal. For example, it is known that it is difficult to adequately control thickness of the resulting sealed tissue by controlling clamping pressure alone for either of two reasons: 1) if too much force is applied, there is a possibility that the two poles will touch and energy will not be transferred through the tissue resulting in an ineffective seal; or 2) if too low a force is applied the tissue may pre-maturely move prior to activation and sealing and/or a thicker, less reliable seal may be created.

Typically and particularly with respect to endoscopic electrosurgical procedures, once a vessel is sealed, the surgeon has to remove the sealing instrument from the operative site, substitute a new instrument through the cannula and accurately sever the vessel along the newly formed tissue seal. As can be appreciated, this additional step may be both time consuming (particularly when sealing a significant number of vessels) and may contribute to imprecise separation of the tissue along the sealing line due to the misalignment or misplacement of the severing instrument along the center of the tissue sealing line.

Several attempts have been made to design an instrument which incorporates a knife or blade member which effectively severs the tissue after forming a tissue seal. For example, U.S. Pat. No. 5,674,220 to Fox et al. discloses a transparent vessel sealing instrument which includes a longitudinally reciprocating knife which severs the tissue once sealed. The instrument includes a plurality of openings which enable direct visualization of the tissue during the sealing and severing process. This direct visualization allows a user to visually and manually regulate the closure force and gap distance between jaw members to reduce and/or limit certain undesirable effects known to occur when sealing vessels, thermal spread, charring, etc. As can be appreciated, the overall success of creating a tissue seal with this instrument is greatly reliant upon the user's expertise, vision, dexterity, and experience in judging the appropriate closure force, gap distance and length of reciprocation of the knife to uniformly, consistently and effectively seal the vessel and separate the tissue at the seal.

U.S. Pat. No. 5,702,390 to Austin et al. discloses a vessel sealing instrument which includes a triangularly-shaped electrode which is rotatable from a first position to seal tissue to a second position to cut tissue. Again, the user must rely on direct visualization and expertise to control the various effects of sealing and cutting tissue.

Thus, a need exists to develop an endoscopic electrosurgical instrument which effectively and consistently seals and separates vascular tissue and solves the aforementioned problems. This instrument regulates the gap distances between opposing jaws members, reduces the chances of short circuiting the opposing jaws during activation and assists in manipulating, gripping and holding the tissue prior to and during activation and separation of the tissue.

SUMMARY

The present disclosure relates to an endoscopic bipolar electrosurgical forceps for clamping, sealing and/or dividing tissue. The forceps includes an elongated shaft having opposing jaw members at a distal end thereof. The jaw members are movable relative to one another from a first position wherein the jaw members are disposed in spaced relation relative to one another to a second position wherein the jaw members cooperate to grasp tissue therebetween. An electrosurgical energy source is connected to the jaw members such that the jaw members are capable of conducting energy through tissue held therebetween to effect a tissue seal. At least one non-conductive and spaced-apart stop member is disposed on an inner-facing surface of at least one of the jaw members and is positioned to control the gap distance between the opposing jaw members when the tissue is held therebetween. A longitudinally reciprocating knife severs the tissue proximate the sealing site once an effective seal is formed.

One embodiment of the presently disclosed forceps includes a drive rod assembly which connects the jaw members to the source of electrical energy such that the first jaw member has a first electrical potential and the second jaw member has a second electrical potential. Preferably, a handle mechanically engages the drive rod assembly and imparts movement of the first and second jaw members relative to one another.

In one embodiment of the present disclosure, one of the jaw members includes an electrically conductive surface having a longitudinally-oriented channel defined therein which facilitates longitudinal reciprocation of the knife for severing tissue. Preferably, the forceps includes a trigger for actuating the knife which is independently operable from the drive assembly.

In one embodiment, the forceps includes at least two stop members arranged as a series of longitudinally-oriented projections which extend along the inner-facing surface from the proximal end to the distal end of the jaw member. In another embodiment, the stop members include a series of circle-like tabs which project from the inner facing surface and extend from the proximal end to the distal end of the jaw member. The stop members may be disposed on either opposing jaw member on opposite sides of the longitudinally-oriented channel and/or in an alternating, laterally-offset manner relative to one another along the length of the surface of either or both jaw members.

In another embodiment of the present disclosure, a raised lip is provided to act as a stop member which projects from the inner-facing surface and extends about the outer periphery of the jaw member to control the gap distance between opposing jaw members. In another embodiment, at least one longitudinally-oriented ridge extends from the proximal end to the distal end of one of the jaw members and controls the gap distance between the jaw members.

Preferably, the stop members are affixed/attached to the jaw member(s) by stamping, thermal spraying, overmolding and/or by an adhesive. The stop members project from about 0.001 inches to about 0.005 inches and, preferably, from about 0.002 inches to about 0.003 inches from the inner-facing surface of at least one of the jaw members. It is envisioned that the stop members may be made from an insulative material such as parylene, nylon and/or ceramic. Other materials are also contemplated, e.g., syndiotactic polystryrenes such as QUESTRA® manufactured by DOW Chemical, Syndiotactic-polystryrene (SPS), Polybutylene Terephthalate (PBT), Polycarbonate (PC), Acrylonitrile Butadiene Styrene (ABS), Polyphthalamide (PPA), Polymide, Polyethylene Terephthalate (PET), Polyamide-imide (PAI), Acrylic (PMMA), Polystyrene (PS and HIPS), Polyether Sulfone (PES), Aliphatic Polyketone, Acetal (POM) Copolymer, Polyurethane (PU and TPU), Nylon with Polyphenylene-oxide dispersion and Acrylonitrile Styrene Acrylate.

Another embodiment of the present disclosure includes an endoscopic bipolar forceps for sealing and dividing tissue having at least one elongated shaft having opposing jaw members at a distal end thereof. The jaw members are movable relative to one another from a first position wherein the jaw members are disposed in spaced relation relative to one another to a second position wherein the jaw members cooperate to grasp tissue therebetween. A drive rod assembly connects the jaw members to a source of electrical energy such that the first jaw member has a first electrical potential and the second jaw member has a second electrical potential. The jaw members, when activated, conduct energy through the tissue held between the jaw members to effect a tissue seal. A handle attaches to the drive rod assembly and, when actuated, imparts movement of the first and second jaw members relative to one another via the drive rod assembly. At least one non-conductive and spaced-apart stop member is disposed on the inner facing surface of one of the jaw members and operates to control the overall gap distance between the opposing seal surfaces of the jaw members when tissue is held therebetween. A trigger mechanically activates a knife for severing the tissue proximate the tissue sealing site.

The present disclosure also relates to a method for sealing and dividing tissue and includes the steps of providing an endoscopic bipolar forceps which includes an elongated shaft having opposing jaw members at a distal end thereof which cooperate to grasp tissue therebetween, at least one non-conductive and spaced-apart stop member disposed on an inner facing surface of at least one of the jaw members which controls the distance between the jaw members when tissue is held therebetween, and a knife.

The method further includes the steps of: connecting the jaw members to a source of electrical energy; actuating the jaw members to grasp tissue between opposing jaw members; conducting energy to the jaw members to through tissue held therebetween to effect a seal; and actuating the knife to sever tissue proximate the seal.

Preferably, at least one of the jaw members of the providing step includes an electrically conductive surface having a longitudinally-oriented channel defined therein which facilitates actuation of the knife in a longitudinally reciprocating fashion within the channel for severing the tissue.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of the subject instrument are described herein with reference to the drawings wherein:

FIG. **1** is a perspective view of an endoscopic forceps showing a handle and an end effector according to the present disclosure;

FIG. **2** is a partial cross-section of the forceps of FIG. **1** showing the internal working components of the handle and showing the end effector in a closed configuration;

FIG. **3** is an enlarged, perspective view of the end effector assembly shown in open configuration;

FIG. **4** is a greatly enlarged, side view of a proximal end of the end effector of FIG. **3**;

FIG. **5** is a greatly enlarged perspective view of a distal end of the end effector of FIG. **3** showing a knife and a series of stop members disposed along an inner facing surface of a jaw member;

FIGS. **6A-6F** show various configurations for the stop members on the inner facing surface of one of the jaw members;

FIG. **7** is an enlarged perspective view of a sealing site of a tubular vessel;

FIG. **8** is a longitudinal cross-section of the sealing site taken along line **8-8** of FIG. **7**; and

FIG. **9** is a longitudinal cross-section of the sealing site of FIG. **7** after separation of the tubular vessel.

DETAILED DESCRIPTION

Referring now to FIGS. **1-5**, one embodiment of an endoscopic bipolar forceps **10** is shown for use with various surgical procedures and includes a housing and handle assembly **80** having an end effector assembly **20** attached thereto. More particularly, forceps **10** includes a shaft **12** which has a distal end **14** dimensioned to mechanically engage with the end effector assembly **20** and a proximal end **16** which mechanically engages the housing and handle assembly **80**. In the drawings and in the descriptions which follow, the term "proximal", as is traditional, will refer to the end of the forceps **10** which is closer to the user, while the term "distal" will refer to the end which is further from the user.

The end effector assembly **20** is attached to the distal end **14** of shaft **12** and includes a pair of opposing jaw members **22** and **24**. Preferably, housing and handle assembly **80** is attached to the proximal end **16** of shaft **12** and includes internally-disposed activating mechanisms, e.g., a movable handle **82** and a drive assembly **70**, which mechanically cooperate to impart movement of the jaw members **22** and **24** from an open position wherein the jaw members **22** and **24** are disposed in spaced relation relative to one another, to a clamping or closed position wherein the jaw members **22** and **24** cooperate to grasp tissue **150** (FIG. **7**) therebetween.

It is envisioned that the forceps **10** may be designed such that it is fully or partially disposable depending upon a particular purpose or to achieve a particular result. For example, end effector assembly **20** may be selectively and releasably engageable with the distal end **14** of the shaft **12** and/or the proximal end **16** of the shaft **12** may be selectively and releasably engageable with the housing and handle assembly **80**. In either of these two instances, the forceps **10** would be considered "partially disposable", i.e., a new or different end effector assembly **20** (or end effector assembly **20** and shaft **12**) selectively replaces the old end effector assembly **20** as needed.

FIGS. **1** and **2** show the operating elements and the internal-working components of the housing and handle assembly **80** which for the purposes of the present disclosure are generally described herein. The specific functions and operative relationships of these elements and the various internal-working components are described in more detail in commonly assigned, co-pending application U.S. Serial No. PCT/US01/11340, entitled "VESSEL SEALER AND DIVIDER" by Dycus et al. which is being filed concurrently herewith and which is hereby incorporated by reference herein in its entirety.

As best shown in FIG. **2**, housing and handle assembly **80** includes movable handle **82** and a fixed handle **84**. The movable handle **82** includes an aperture **89** defined therethrough which enables a user to grasp and move the handle **82** relative to the fixed handle **84**. Movable handle **82** is selectively moveable about a pivot **87** from a first position relative to fixed handle **84** to a second position in closer proximity to the fixed handle **84** which, as explained below, imparts relative movement of the jaw members **22** and **24** relative to one another.

More particularly, housing and handle assembly **80** houses a drive assembly **70** which cooperates with the movable handle **82** to impart movement of the jaw members **22** and **24** from an open position wherein the jaw members **22** and **24** are disposed in spaced relation relative to one another, to a clamping or closed position wherein the jaw members **22** and **24** cooperate to grasp tissue **150** (FIG. **7**) therebetween. The general operating parameters of the drive assembly **70** and the internal-working components of the same are explained in a more generalized fashion below but are explained in specific detail in the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application. For the purposes of the present disclosure, the housing and handle assembly **80** can generally be characterized as a four-bar mechanical linkage composed of the following elements: movable handle **82**, a link

73, a cam-like link **76** and a base link embodied by fixed pivot points **75** and **76**. Movement of the handle **82** activates the four-bar linkage which, in turn, actuates the drive assembly **70** for imparting movement of the opposing jaw members **22** and **24** relative to one another to grasp tissue **150** therebetween. It is envisioned that employing a four-bar mechanical linkage will enable the user to gain a significant mechanical advantage when compressing the jaw members **22** and **24** against the tissue **150** as explained in further detail below with respect the generally disclosed operating parameters of the drive assembly **70**.

Preferably, fixed handle **84** includes a channel **85** defined therein which is dimensioned to receive a flange **83** which extends proximally from movable handle **82**. Preferably, flange **83** includes a fixed end **90** which is affixed to movable handle **82** and a free end **92** which is dimensioned for facile reception within channel **85** of handle **84**. It is envisioned that flange **83** may be dimensioned to allow a user to selectively, progressively and incrementally move jaw members **22** and **24** relative to one another from the open to closed positions. For example, it is also contemplated that flange **83** may include a ratchet-like interface which lockingly engages the movable handle **82** and, therefore, jaw members **22** and **24** at selective, incremental positions relative to one another depending upon a particular purpose. Other mechanisms may also be employed to control and/or limit the movement of handle **82** relative to handle **84** (and jaw members **22** and **24**) such as, e.g., hydraulic, semi-hydraulic and/or gearing systems.

As can be appreciated by the present disclosure and as explained in more detail with respect to the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application, channel **85** of fixed handle **84** includes an entrance pathway **91** and an exit pathway **95** for reciprocation of flange **83**. As best shown in FIG. **2**, as handle **82** moves in a generally pivoting fashion towards fixed handle **84** about pivot **87**, link **73** rotates about a guide pin **74** disposed within handle **82**. As a result, link **73** rotates proximally about a pivot **76**. As can be appreciated, the pivoting path of handle **82** relative to fixed handle **84** biases cam-like link **76** to rotate about pivot **75** in a generally proximal direction. Movement of the cam-like link **76** imparts movement to the drive assembly **70** as explained below.

As best shown in FIG. **2**, upon initial movement of handle **82** towards fixed handle **84**, the free end **92** of flange **83** moves generally proximally and upwardly along entrance pathway **91** until end **92** passes or mechanically engages a rail member **97** disposed along pathway **91**. It is envisioned that rail **97** permits movement of flange **83** proximally until the point where end **92** clears rail **97**. Once end **92** clears rail **97**, distal movement of the handle **82** and flange **83**, i.e., release, is redirected by rail **97** into the exit pathway **95**.

More particularly, upon initial release, i.e., a reduction in the closing pressure of handle **82** against handle **84**, the handle **82** returns slightly distally towards pathway **91** but is directed towards exit pathway **95**. At this point, the release or return pressure between the handles **82** and **84** which is attributable and directly proportional to the release pressure associated with the compression of the drive assembly **70** (explained below) causes the end **92** of flange **83** to settle or lock within a catch basin **93**. Handle **82** is now secured in position within handle **84** which, in turn, locks the jaw members **22** and **24** in a closed position against the tissue. The instrument is now positioned for selective application of electrosurgical energy to form the tissue seal **152**. Again, the various operating elements and their relevant functions are explained in more detail with respect to the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application.

As best shown in FIG. **2**, re-initiation or re-grasping of the handle **82** again moves flange **83** generally proximally along the newly re-directed exit path **95** until end **92** clears a lip **94** disposed along exit pathway **95**. Once lip **94** is sufficiently cleared, handle **82** and flange **83** are fully and freely releasable from handle **84** along exit pathway **95** upon the reduction of grasping pressure which, in turn, returns the jaw members **22** and **24** to the open, pre-activated position.

As mentioned above, the housing and handle assembly **80** houses a drive assembly **70** which cooperates with the movable handle **82** to impart relative movement of the jaw members **22** and **24** to grasp the tissue **150**. The operation of the drive rod assembly **70** and the various working components of the drive assembly **70** are explained in detail in the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application.

Generally and for the purposes of the present disclosure, the drive assembly **70** includes a compression spring **72**, a drive rod **40** and a compression sleeve **98** (FIG. **2**). As best shown in the enlarged view of FIG. **4**, the drive rod **40** is telescopically and internally reciprocable within a knife sleeve **48**. Movement of the drive rod **40** relative to the knife sleeve **48** imparts movement to the jaw members **22** and **24**. A tab member **46** is disposed at a free end **42** of the drive rod **40** which defines a notch **43** between the tab **46** and end **42**. The tab **46** and the notch **43** mechanically cooperate with the compression spring **72** to impart movement of the shaft **40** relative to the knife sleeve **48** which, in turn, opens and closes the jaw members **22** and **24** about the tissue **150**.

As explained above, movement of the handle assembly **80** via the four-bar linkage, ultimately causes cam-like link **76** to rotate generally clockwise about pivot **75** (i.e. proximally) which, in turn, compresses spring **72** proximally against a flange **77** disposed within the upper portion of the fixed handle **84**. Movement of the spring **72**, in turn, moves the drive rod **40** relative to the knife sleeve **48** which moves the opposing jaw members **22** and **24** relative to one another. As can be appreciated, the significant mechanical advantage associated with the four-bar linkage permits facile, consistent and uniform compression of the spring **72** which, in turn, permits facile, consistent and uniform compression of the jaw members **22** and **24** about the tissue **150**. Other details and advantages of the four-bar mechanical linkage are more fully discussed with respect to the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application.

Once the tissue **150** is grasped between opposing jaw members **22** and **24**, electrosurgical energy can be supplied to the jaw members **22** and **24** through an electrosurgical interface **110** disposed within the handle **84**. Again these features are explained in more detail with respect to the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application.

Forceps **10** also includes a trigger **86** which reciprocates the knife sleeve **48** which, in turn, reciprocates a knife **60** disposed within the end effector assembly **20** as explained below (FIG. **5**). Once the a tissue seal **152** is formed (FIG. **7**), the user can activate the trigger **86** to separate the tissue **150** as shown in FIG. **9** along the tissue seal **152**. As can be appreciated, the reciprocating knife **60** allows the user to quickly separate the tissue **150** immediately after sealing without substituting a cutting instrument through the cannula or trocar port (not shown). It is envisioned that the knife **60** also facilitates a more accurate separation of the vessel

150 along an ideal cutting plane "B-B" associated with the newly formed tissue seal **152** (See FIGS. **7-9**). Knife **60** preferably includes a sharpened edge **62** for severing the tissue **150** held between the jaw members **22** and **24** at the tissue sealing site **152** (FIG. **7**). It is envisioned that knife **60** may also be coupled to the electrosurgical energy source to facilitate separation of the tissue **150** along the tissue seal **152**.

Preferably and as explained in more detail with respect to the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application, handle assembly **80** may also include a lockout mechanism (not shown) which restricts activation of trigger **86** until the jaw members **22** and **24** are closed and/or substantially closed about tissue **150**. For example and as best seen in FIG. **2**, exit pathway **95** may be dimensioned such that the trigger **86** is only activatable when flange **83** is disposed in a predetermined or predefined position which provides sufficient clearance for the activation of the trigger **86**, e.g., seated within catch basin **93**. It is envisioned that configuring the handle assembly **80** in this fashion may reduce the chances of premature activation of the trigger **86** prior to electrosurgical activation and sealing.

A rotating assembly **88** may also be incorporated with forceps **10**. Preferably, rotating assembly **88** is mechanically associated with the shaft **12** and the drive assembly **70**. As seen best in FIG. **4**, the shaft **12** includes an aperture **44** located therein which mechanically interfaces a corresponding detent (not shown) affixed to rotating assembly **88** such that rotational movement of the rotating assembly **88** imparts similar rotational movement to the shaft **12** which, in turn, rotates the end effector assembly **20** about a longitudinal axis "A". These features along with the unique electrical configuration for the transference of electrosurgical energy through the handle assembly **80**, the rotating assembly **88** and the drive assembly **70** are described in more detail in the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application.

As best seen with respect to FIGS. **3**, **5** and **6**A-**6**F, end effector assembly **20** attaches to the distal end **14** of shaft **12**. The end effector assembly **20** includes the first jaw member **22**, the second jaw member **24** and the reciprocating knife **60** disposed therebetween. The jaw members **22** and **24** are preferably pivotable about a pivot **37** from the open to closed positions upon relative reciprocation, i.e., longitudinal movement, of the drive rod **42** as mentioned above. Again, the mechanical and cooperative relationships with respect to the various moving elements of the end effector assembly **20** are further described with respect to the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application.

Each of the jaw members includes an electrically conductive sealing surface **35** dispose on inner-facing surface **34** thereof and an insulator **30** disposed on an outer-facing surface **39** thereof. It is envisioned that the electrically conductive surfaces **35** cooperate to seal tissue **150** held therebetween upon the application of electrosurgical energy. The insulators **30** together with the outer, non-conductive surfaces **39** of the jaw members **22** and **24** are preferably dimensioned to limit and/or reduce many of the known undesirable effects related to tissue sealing, e.g., flashover, thermal spread and stray current dissipation.

It is envisioned that the electrically conductive sealing surfaces **35** may also include a pinch trim which facilitates secure engagement of the electrically conductive surface **35** to the insulator **30** and also simplifies the overall manufacturing process. It is envisioned that the electrically conductive sealing surface **35** may also include an outer peripheral edge which has a radius and the insulator **30** meets the electrically conductive sealing surface **35** along an adjoining edge which is generally tangential to the radius and/or meets along the radius. Preferably, at the interface, the electrically conductive surface **35** is raised relative to the insulator **30**. These and other envisioned embodiments are discussed in concurrently-filed, co-pending, commonly assigned Application Serial No. PCT/US01/11412 entitled "ELECTROSURGICAL INSTRUMENT WHICH REDUCES COLLATERAL DAMAGE TO ADJACENT TISSUE" by Johnson et al. and concurrently-filed, co-pending, commonly assigned Application Serial No. PCT/US01/11411 entitled "ELECTROSURGICAL INSTRUMENT WHICH IS DESIGNED TO REDUCE THE INCIDENCE OF FLASHOVER" by Johnson et al. The entire contents of both of these applications are hereby incorporated by reference herein.

Preferably, a least one of the electrically conductive surfaces **35** of the jaw members, e.g., **22**, includes a longitudinally-oriented channel **36** defined therein which extends from a proximal end **26** to a distal end **28** of the jaw member **22**. It is envisioned that the channel **36** facilitates longitudinal reciprocation of the knife **60** along a preferred cutting plane "B-B" to effectively and accurately separate the tissue **150** along the formed tissue seal **152** (See FIGS. **7-9**). Preferably and as explained in detail in the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application, the jaw members **22** and **24** of the end effector assembly **22** are electrically isolated from one another such that electrosurgical energy can be effectively transferred through the tissue **150** to form seal **152**.

As mentioned above, upon movement of the handle **82**, the jaw members **22** and **24** close together and grasp tissue **150**. At this point flange **83** becomes seated within catch **93** which, together with the mechanical advantage associated with the four-bar mechanism and the spring **70**, maintains a proportional axial force on the drive rod **40** which, in turn, maintains a compressive force between opposing jaw members **22** and **24** against the tissue **150**. It is envisioned that the end effector assembly **20** may be dimensioned to off-load excessive clamping forces to prevent mechanical failure of certain internal operating elements of the end effector.

By controlling the intensity, frequency and duration of the electrosurgical energy applied to the tissue **150**, the user can either cauterize, coagulate/desiccate seal and/or simply reduce or slow bleeding. As mentioned above, two mechanical factors play an important role in determining the resulting thickness of the sealed tissue and effectiveness of the seal, i.e., the pressure applied between opposing jaw members **22** and **24** and the gap distance between the opposing sealing surfaces **35** of the jaw members **22** and **24** during the sealing process. However, thickness of the resulting tissue seal **152** cannot be adequately controlled by force alone. In other words, too much force and the two jaw members **22** and **24** would touch and possibly short resulting in little energy traveling through the tissue **150** thus resulting in a bad tissue seal **152**. Too little force and the seal **152** would be too thick.

Applying the correct force is also important for other reasons: to oppose the walls of the vessel; to reduce the tissue impedance to a low enough value that allows enough current through the tissue **150**; and to overcome the forces of expansion during tissue heating in addition to contributing towards creating the required end tissue thickness which is an indication of a good seal.

Preferably, the electrically conductive sealing surfaces **35** of the jaw members **22** and **24** are relatively flat to avoid current concentrations at sharp edges and to avoid arcing between high points. In addition and due to the reaction force of the tissue **150** when engaged, jaw members **22** and **24** are preferably manufactured to resist bending. For example and as best seen in FIG. **6**A, the jaw members **22** and **24** are preferably tapered along width "W" which is advantageous for two reasons: 1) the taper will apply constant pressure for a constant tissue thickness at parallel; 2) the thicker proximal portion of the jaw members **22** and **24** will resist bending due to the reaction force of the tissue **150**.

As best seen in FIGS. **5**-**6**F, in order to achieve a desired spacing between the electrically conductive surfaces **35** of the respective jaw members **22** and **24**, (i.e., gap distance) and apply a desired force to seal the tissue **150**, at least one jaw member **22** and/or **24** includes at least one stop member, e.g., **50***a*, which limits the movement of the two opposing jaw members **22** and **24** relative to one another. Preferably, the stop member, e.g., **50***a*, extends from the sealing surface or tissue contacting surface **35** a predetermined distance according to the specific material properties (e.g., compressive strength, thermal expansion, etc.) to yield a consistent and accurate gap distance during sealing. Preferably, the gap distance between opposing sealing surfaces **35** during sealing ranges from about 0.001 inches to about 0.005 inches and, more preferably, between about 0.002 and about 0.003 inches.

Preferably, stop members **50***a*-**50***g* are made from an insulative material, e.g., parylene, nylon and/or ceramic and are dimensioned to limit opposing movement of the jaw members **22** and **24** to within the above mentioned gap range. It is envisioned that the stop members **50***a*-**50***g* may be disposed on one or both of the jaw members **22** and **24** depending upon a particular purpose or to achieve a particular result.

FIGS. **6**A-**6**F show various contemplated configurations of the non-conductive stop members **50***a*-**50***g* disposed on, along or protruding through the jaw member **24**. It is envisioned that one or more stop members, e.g., **50***a* and **50***g*, can be positioned on either or both jaw members **22** and **24** depending upon a particular purpose or to achieve a desired result. As can be appreciated by the present disclosure, the various configurations of the stop members **50***a*-**50***g* are designed to both limit the movement of the tissue **150** prior to and during activation and prevent short circuiting of the jaw members **22** and **24** as the tissue **150** is being compressed.

FIGS. **6**A and **6**B show one possible configuration of the stop members **50***a*-**50***g* for controlling the gap distance between opposing seal surfaces **35**. More particularly, a pair of longitudinally-oriented tab-like stop members **50***a* are disposed proximate the center of sealing surface **35** on one side of the knife channel **36** of jaw member **24**. A second stop member, e.g., **50***b*, is disposed at the proximal end **26** of jaw member **24** and a third stop member **50***g* is disposed at the distal tip **28** of jaw member **24**. Preferably, the stop members **50***a*-**50***g* may be configured in any known geometric or polynomial configuration, e.g., triangular, rectilinear, circular, ovoid, scalloped, etc., depending upon a particular purpose. Moreover, it is contemplated that any combination of different stop members **50***a*-**50***g* may be assembled along the sealing surfaces **35** to achieve a desired gap distance. It is also envisioned that the stop members may be designed as a raised lip (not shown) which projects from the outer periphery of the jaw member **24**.

FIG. **6**C shows a first series of circle-like stop members **50***c* extending from the proximal end **26** to the distal end **28** of jaw member **24** in an alternating, laterally-offset manner relative to one another on one side of the knife channel **36** and a second series of circle-like stop members **50***c* extending from the proximal end **26** to the distal end **28** of jaw member **24** in an alternating, laterally-offset manner relative to one another on the other side of the knife channel **36**. It is envisioned that circle-like stop members **50***c* are substantially equal in size, however, one or more of the stop members **50***c* may be dimensioned larger or smaller than the other stop members **50***c* depending upon a particular purpose or to achieve a desired result.

FIG. **6**D shows yet another configuration wherein the stop member is configured as a longitudinally-oriented ridge **50***e* extending from a proximal end **26** to a distal end **28** of jaw member **82** along one side of knife channel **36**. As mentioned above, a second longitudinally-oriented ridge **50***e* may be disposed on opposing jaw member **22** on the opposite side of knife channel **36** for sealing purposes. FIG. **6**E shows a series of elongated tab-like members **50***f* which are disposed at an angle relative to knife channel **36**. FIG. **6**F shows yet another configuration wherein different stop members, e.g., **50***a*, **50***c* and **50***g* are disposed atop sealing surface **35** on both sides of the knife channel **36**.

Preferably, the non-conductive stop members **50***a*-**50***g* are molded onto the jaw members **22** and **24** (e.g., overmolding, injection molding, etc.), stamped onto the jaw members **22** and **24** or deposited (e.g., deposition) onto the jaw members **22** and **24**. The stop members **50***a*-**50***g* may also be slideably attached to the jaw members and/or attached to the electrically conductive surfaces **35** in a snap-fit manner Other techniques involve thermally spraying a ceramic material onto the surface of the jaw member **22** and **24** to form the stop members **50***a*-**50***g*. Several thermal spraying techniques are contemplated which involve depositing a broad range of heat resistant and insulative materials on the electrically conductive surfaces **35** to create stop members **50***a*-**50***g*, e.g., High velocity Oxy-fuel deposition, plasma deposition, etc.

It is envisioned that the stop members **50***a*-**50***g* protrude about 0.001 to about 0.005 inches from the inner-facing surfaces **35** of the jaw members **22** and **24** which, as can be appreciated by the present disclosure, both reduces the possibility of short circuiting between electrically conductive surfaces and enhances the gripping characteristics of the jaw members **22** and **24** during sealing and dividing. Preferably, the stop members **50***a*-**50***g* protrude about 0.002 inches to about 0.003 inches from the electrically conductive surface **35** which has been determined yield an ideal gap distance for producing effective, uniform and consistent tissue seals.

Alternatively, the stop members **50***a*-**50***g* can be molded onto the inner-facing surface **35** of one or both jaw members **22** and **24** or, in some cases, it may be preferable to adhere the stop member **50***a*-**50***g* to the inner facing surfaces **35** of one or both of the jaw members **22** and **24** by any known method of adhesion. Stamping is defined herein to encompass virtually any press operation known in the trade, including but not limited to: blanking, shearing, hot or cold forming, drawing, bending, and coining.

FIGS. **6**A-**6**F show some of the possible configurations of the stop members **50***a*-**50***f*, however, these configurations are shown by way of example and should not be construed as limiting. Other stop member configurations are also contemplated which may be may be equally effective in reducing the possibility of short circuiting between electrically conductive surfaces **35** and enhancing tissue grip during sealing and dividing.

Further, although it is preferable that the stop members **50***a*-**50***g* protrude about 0.001 inches to about 0.005 and preferably about 0.002 inches to about 0.003 inches from the inner-facing surfaces **35** of the jaw member **22** and **24**, in some cases it may be preferable to have the stop members **50***a*-**50***g* protrude more or less depending upon a particular purpose. For example, it is contemplated that the type of material used for the stop members **50***a*-**50***g* and that material's ability to absorb the large compressive closure forces between jaw members **22** and **24** will vary and, therefore, the overall dimensions of the stop members **50***a*-**50***g* may vary as well to produce the desired gap distance.

In other words, the compressive strength of the material along with the desired or ultimate gap distance required for effective sealing are parameters which are carefully considered when forming the stop members **50***a*-**50***g* and one material may have to be dimensioned differently from another material to achieve the same gap distance or desired result. For example, the compressive strength of nylon is different from ceramic and, therefore, the nylon material may have to be dimensioned differently, e.g., thicker, to counteract the closing force of the opposing jaw members **22** and **24** and to achieve the same desired gap distance when utilizing a ceramic stop member.

The present disclosure also relates to a method of sealing and dividing tissue and includes the steps of providing an endoscopic bipolar forceps **10** which includes an elongated shaft **12** having opposing jaw members **22** and **24** at a distal end **14** thereof which cooperate to grasp tissue **150** therebetween, at least one non-conductive and spaced-apart stop member **50***a*-**50***g* disposed on an inner facing surface **35** of at least one of the jaw members, e.g., **24**, which controls the distance between the jaw members **22** and **24** when tissue **150** is held therebetween, and a knife **60**.

The method further includes the steps of: connecting the jaw members **22** and **24** to a source **110** of electrical energy; actuating the jaw members **22** and **24** to grasp tissue **150** between opposing jaw members **22** and **24**; conducting energy to the jaw members **22** and **24** to through tissue **150** held therebetween to effect a seal **152** (FIGS. **7**-**9**); and actuating the knife **60** to sever tissue proximate the seal **152**.

Preferably, at least one of the jaw members, e.g., **24**, of the providing step includes an electrically conductive surface **35** having a longitudinally-oriented channel **36** defined therein which facilitates actuation of the knife **60** in a longitudinally reciprocating fashion within the channel **36** for severing the tissue **150** proximate the tissue site.

From the foregoing and with reference to the various figure drawings, those skilled in the art will appreciate that certain modifications can also be made to the present disclosure without departing from the scope of the present disclosure. For example, it may be preferable to add other features to the forceps **10**, e.g., an articulating assembly to axially displace the end effector assembly **20** relative to the elongated shaft **12**.

Moreover, it is contemplated that the presently disclosed forceps may include a disposable end effector assembly which is selectively engageable with at least one portion of the electrosurgical instrument, e.g., shaft **12** and/or handle assembly **80**.

While several embodiments of the disclosure have been shown in the drawings, it is not intended that the disclosure be limited thereto, as it is intended that the disclosure be as broad in scope as the art will allow and that the specification be read likewise. Therefore, the above description should not be construed as limiting, but merely as exemplifications of a preferred embodiments. Those skilled in the art will envision other modifications within the scope and spirit of the claims appended hereto.

What is claimed is:

1. A bipolar electrosurgical instrument, comprising:

a housing;

a shaft extending distally from the housing;

first and second jaw members disposed at a distal end of the shaft, the first and second jaw members including first and second seal surfaces, respectively, the first and second seal surfaces defining first and second knife channels, respectively, at least one of the first or second jaw members movable relative to the other from a open position to a closed position to grasp tissue between the first and second seal surfaces, the first and second seal surfaces adaptable to connect to a source of electrical energy such that the first and second seal surfaces are capable of conducting energy through tissue grasped therebetween;

a drive rod extending from the housing and through the shaft, the drive rod operably coupled with at least one of the first or second jaw members such that proximal translation of the drive rod moves the at least one of the first or second jaw members relative to the other to the closed position;

a drive linkage including at least a first end portion and a second end portion;

a movable handle coupled to the housing and movable proximally relative to a fixed handle portion of the housing from a spaced-apart position to an approximated position, the movable handle pivotably connected to the first end portion of the drive linkage;

a spring disposed within the housing, wherein a first end portion of the spring is operably coupled to the second end portion of drive linkage and wherein a second end portion of the spring is operably coupled to the drive rod, wherein movement of the drive linkage, in response to proximal movement of the movable handle from the spaced-apart position towards the approximated position moves the spring proximally to translate the drive rod proximally to thereby move the at least one of the first or second jaw members relative to the other to the closed position to maintain a compressive force between the first and second jaw members about tissue grasped between the first and second seal surfaces;

at least one stop member disposed on at least one of the first or second jaw members, the at least one stop member configured to regulate a gap distance between the first and second sealing surfaces in the closed position, wherein the gap distance and the compressive force facilitate sealing tissue grasped between the first and second sealing surfaces; and

a knife configured to translate through the first and second knife channels to cut sealed tissue.

2. The bipolar electrosurgical instrument according to claim **1**, wherein the movable handle is configured to move the drive linkage to rotate and wherein rotation of the drive link moves the spring.

3. The bipolar electrosurgical instrument according to claim **1**, further comprising a ratchet associated with the fixed handle portion of the housing and the movable handle, the ratchet including flange and a channel, the flange configured to engage the channel upon actuation of the movable handle to lock the movable handle relative to the fixed handle portion of the housing, thereby locking the first and second jaw members in the closed position.

4. The bipolar electrosurgical instrument according to claim **1**, further comprising a trigger pivotably coupled to the housing and operably coupled to the knife, wherein actuation of the trigger moves translates the knife through the first and second knife channels.

5. The bipolar electrosurgical instrument according to claim **4**, further comprising a knife sleeve extending from the housing and through the shaft, the knife sleeve operably coupling the trigger with the knife, wherein actuation of the trigger translates the knife sleeve to thereby translate the knife through the first and second knife channels.

6. The bipolar electrosurgical instrument according to claim **1**, wherein the first and second seal surfaces are disposed on inwardly-facing surfaces of the first and second jaw members, respectively, and wherein each of the first and second jaw members further includes an insulator disposed on an outwardly-facing surface thereof.

7. The bipolar electrosurgical instrument according to claim **1**, wherein the at least one stop member includes a plurality of stop members.

8. The bipolar electrosurgical instrument according to claim **1**, further comprising a tab extending from the drive rod, wherein movement of the spring urges the spring into the tab to translate the drive rod to thereby move the at least one of the first or second jaw members relative to the other to the closed position.

9. The bipolar electrosurgical instrument according to claim **8**, wherein the spring is compressed against the tab to translate the drive rod.

10. The bipolar electrosurgical instrument according to claim **1**, wherein the spring is disposed about the drive rod.

11. The bipolar electrosurgical instrument according to claim **10**, wherein the spring is a compression coil spring.

12. The bipolar electrosurgical instrument according to claim **10**, wherein the spring and the drive rod are aligned on a longitudinal axis extending through the shaft.

13. The bipolar electrosurgical instrument according to claim **1**, wherein both of the first and second jaw members are movable from the open position to the closed position.

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